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**Belagali**

(10) **Patent No.: US 9,192,394 B2**
(45) **Date of Patent: Nov. 24, 2015**

(54) **SURGICAL HANDPIECE WITH A COMPACT CLUTCH**

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(73) Assignee: **STRYKER CORPORATION**, Kalamazoo, MI (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 81 days.

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(22) Filed: **Mar. 12, 2013**

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**Related U.S. Application Data**

(62) Division of application No. 11/471,266, filed on Jun. 20, 2006, now Pat. No. 8,419,760.

(60) Provisional application No. 60/693,638, filed on Jun. 25, 2005.

(51) **Int. Cl.**
***A61B 17/16*** (2006.01)
***B23B 31/107*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ........... ***A61B 17/1622*** (2013.01); ***A61B 17/162*** (2013.01); ***A61B 17/1624*** (2013.01); ***B23B 31/1074*** (2013.01); ***B23B 45/008*** (2013.01); ***B25F 5/001*** (2013.01); *A61B 17/1631* (2013.01); *A61B 17/32002* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC ............. A61B 17/162; A61B 17/1622; A61B 17/1624; A61B 17/1631; A61B 17/1626; A61B 17/1628; A61B 17/1617; A61B 17/1615; A61B 17/1613; A61B 2017/00367; A61B 17/32002; A61B 2017/00464; A61B 2017/00734; A61B 2017/00477; A61B 2017/320032; B23B 31/1207; B23B 31/1074; B23B 45/008; B25F 5/001; B25F 23/0035; Y10T 408/6776; Y10T 408/6779; Y10T 408/6771; Y10T 408/66; Y10T 408/70; Y10T 408/72; Y10T 408/65; Y10T 279/3418
See application file for complete search history.

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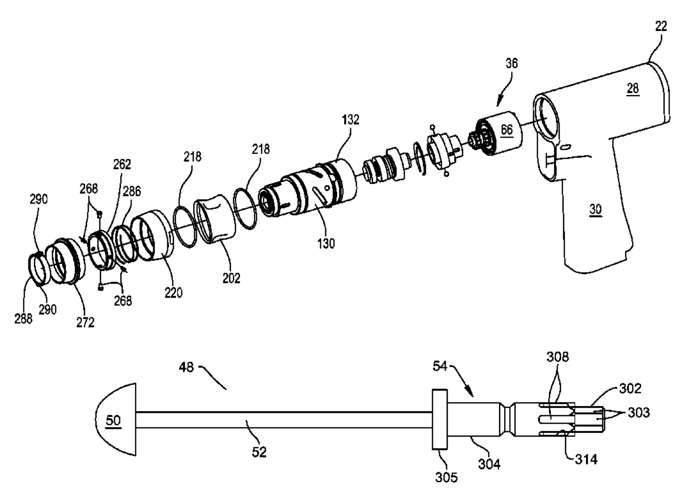
*Primary Examiner* — Jocelin Tanner

(57) **ABSTRACT**

A surgical handpiece with a rotating spindle for receiving the coupling head of a surgical attachment or a cutting accessory. A gear train has plural drive heads that simultaneously rotate at different speeds. A clutch assembly has pins that move along the length of the spindle. The clutch assembly sets the position of the pins so they will engage one of the drive heads. The spindle rotates with the drive head with which the clutch pins are engaged.

**29 Claims, 20 Drawing Sheets**



(51) **Int. Cl.**

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| ***B23B 45/00*** | (2006.01) |
| ***B25F 5/00*** | (2006.01) |
| *A61B 17/32* | (2006.01) |
| *A61B 17/00* | (2006.01) |

(52) **U.S. Cl.**

CPC ................. *A61B 2017/00464* (2013.01); *A61B 2017/00477* (2013.01); *A61B 2017/00734* (2013.01); *A61B 2017/320032* (2013.01); *Y10T 279/3418* (2015.01)

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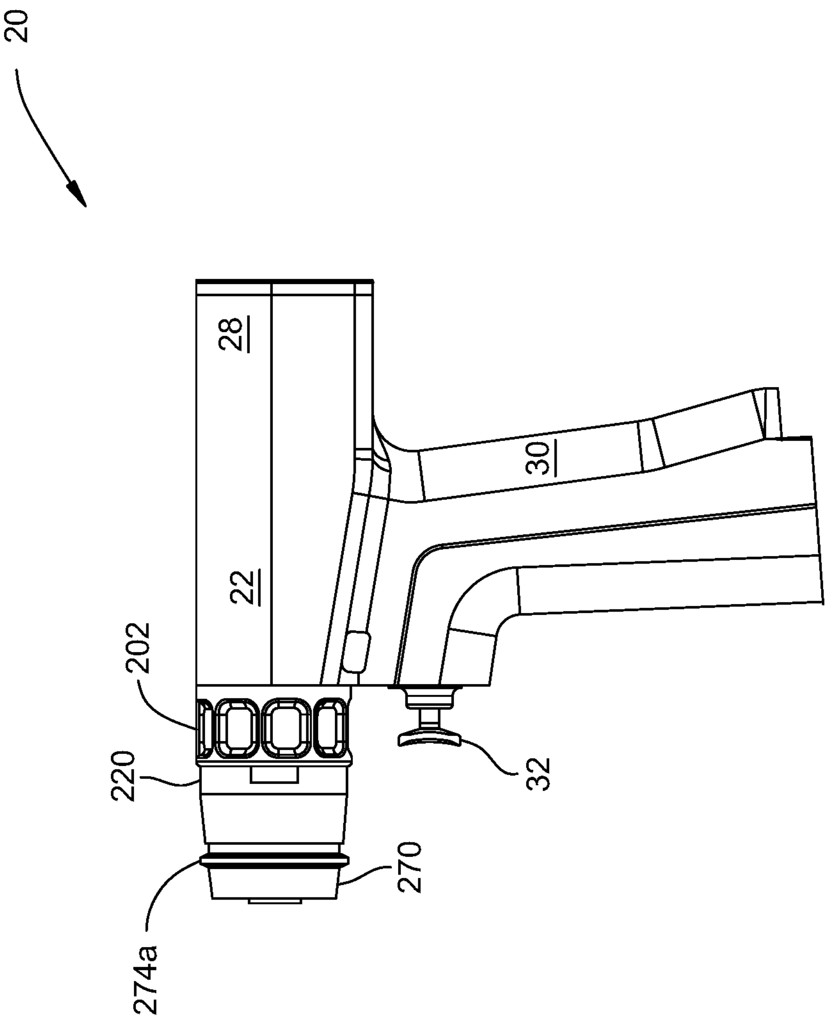


FIG. 1

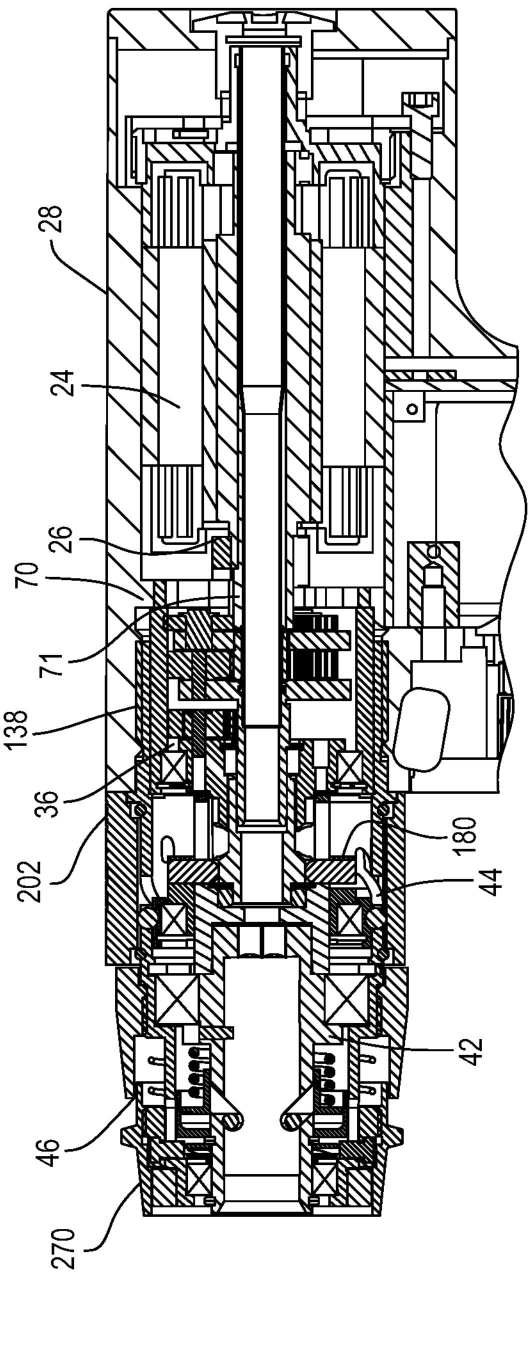


FIG. 2

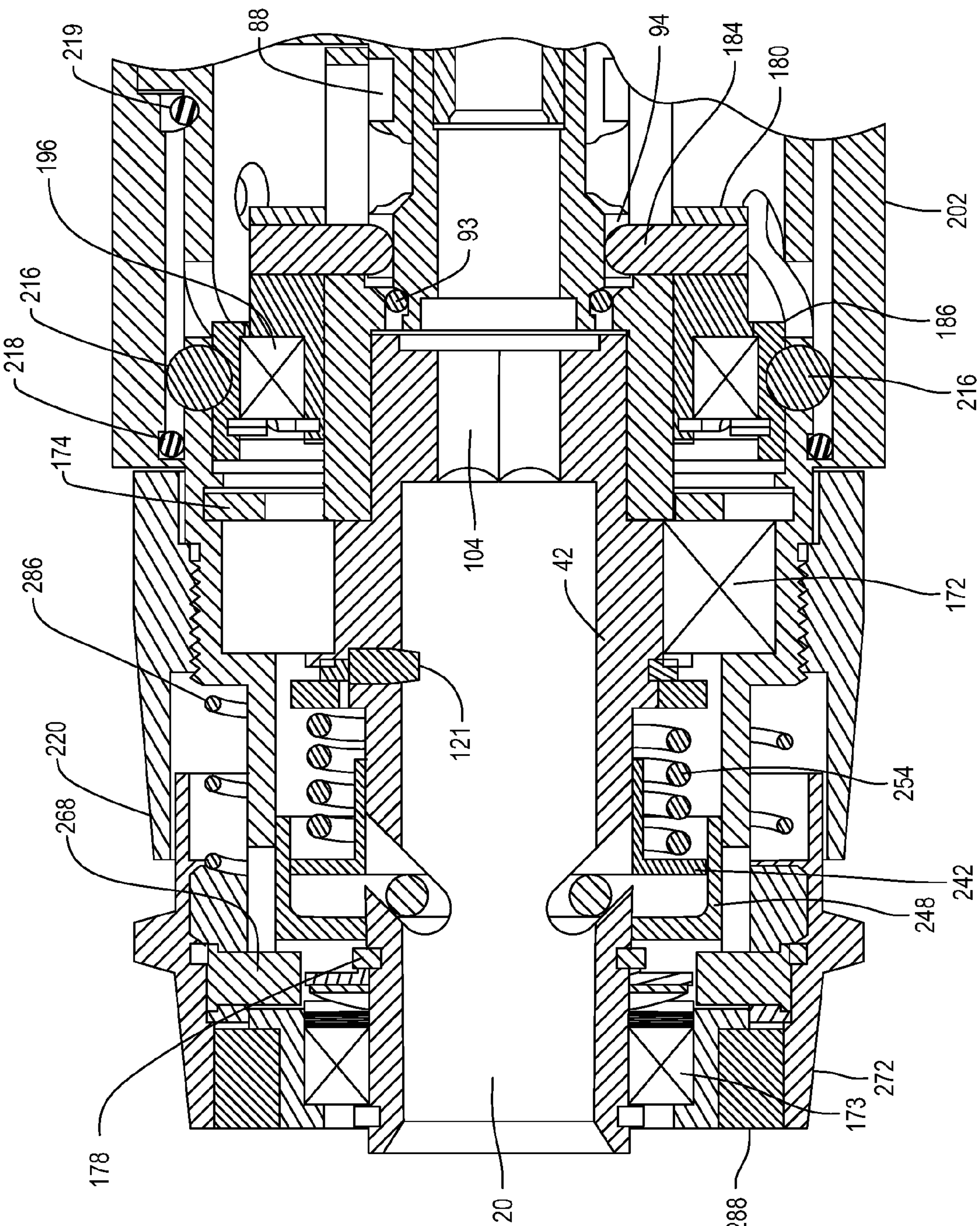
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FIG. 2A

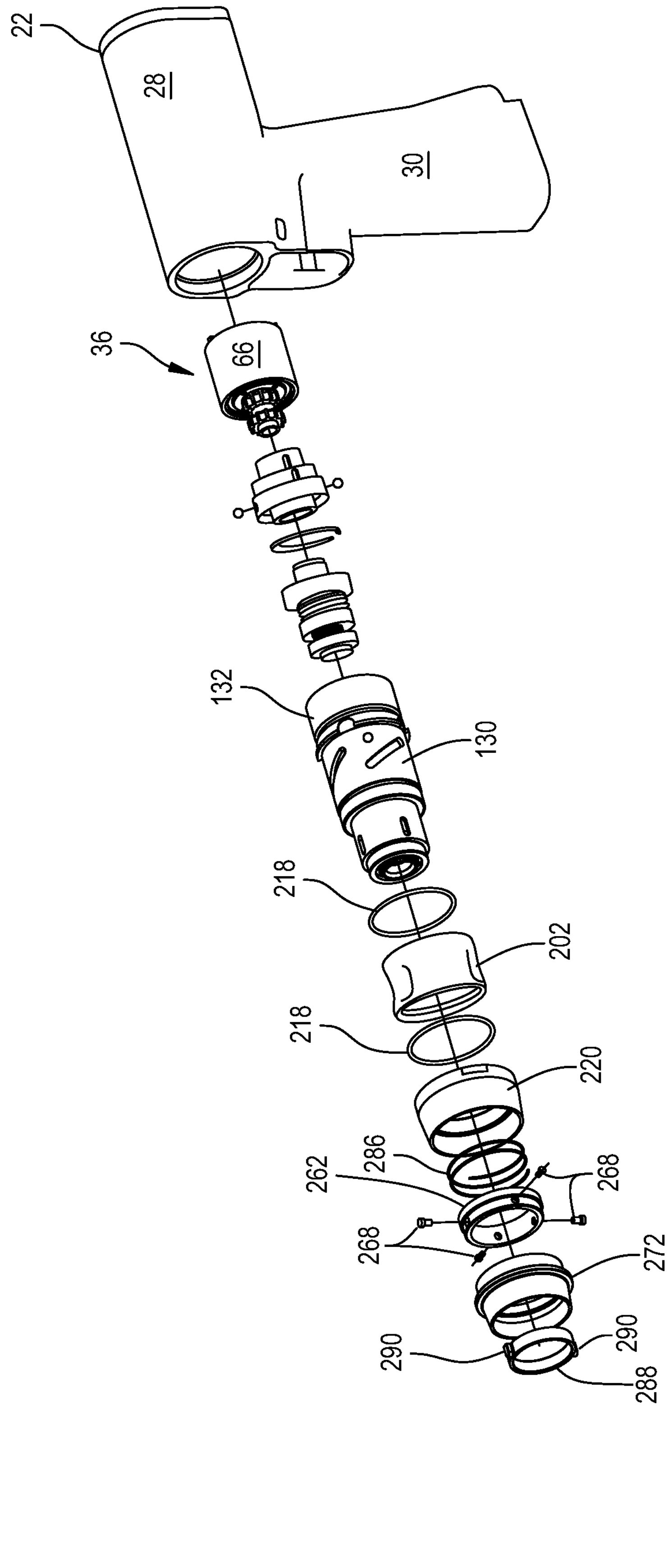
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FIG. 3

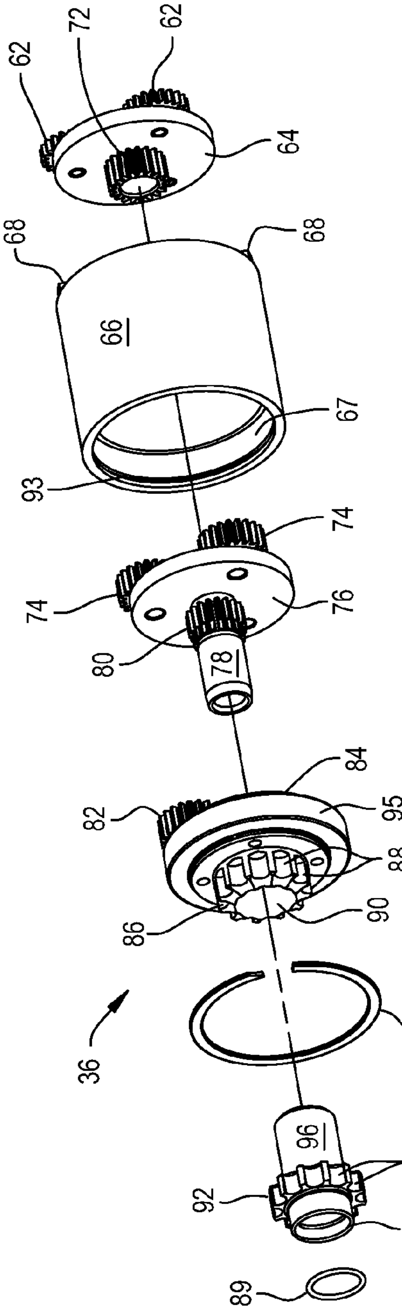
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FIG. 4

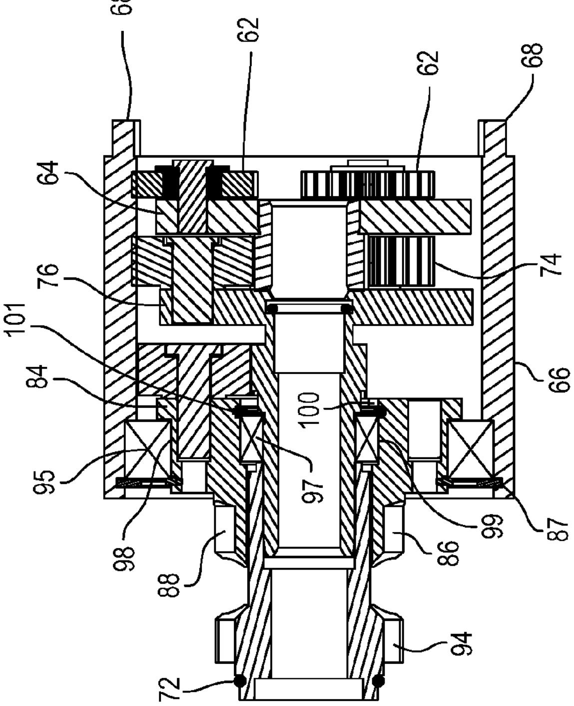
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FIG. 5

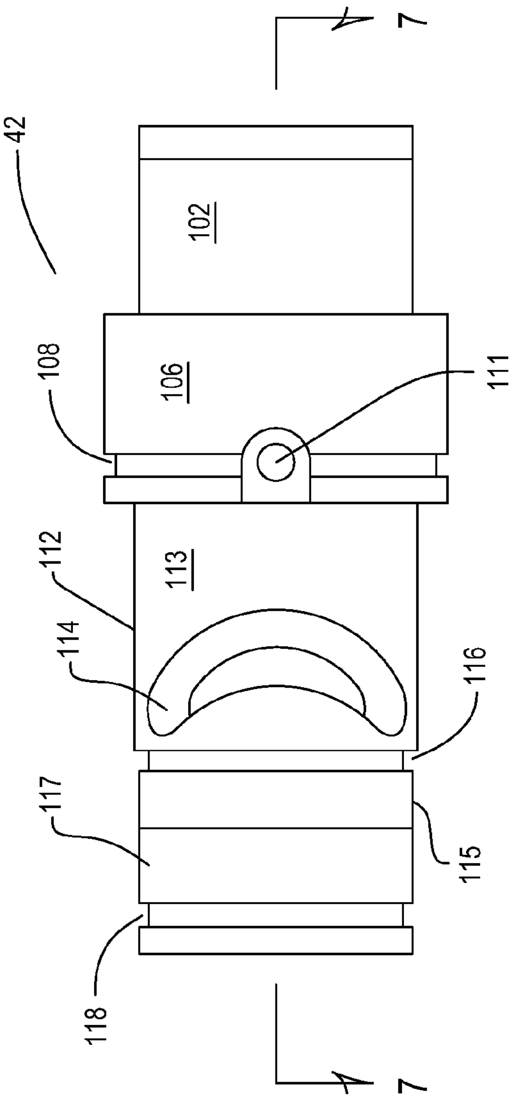

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FIG. 6

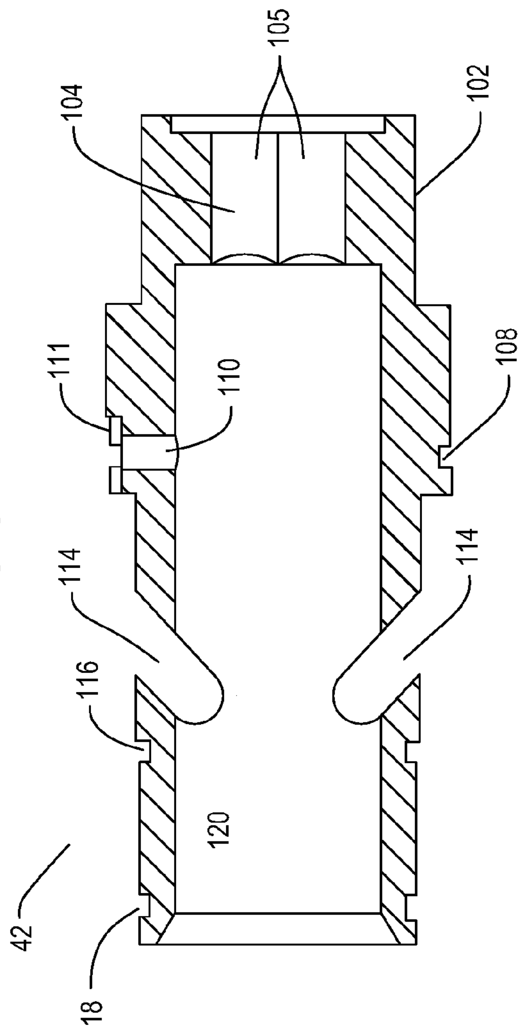

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FIG. 7

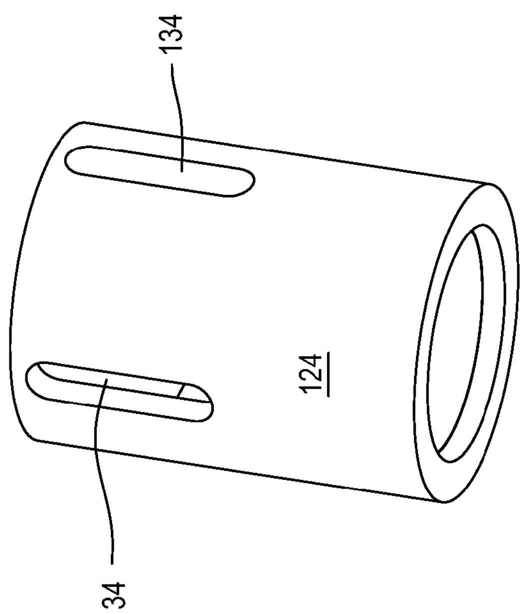



FIG. 8

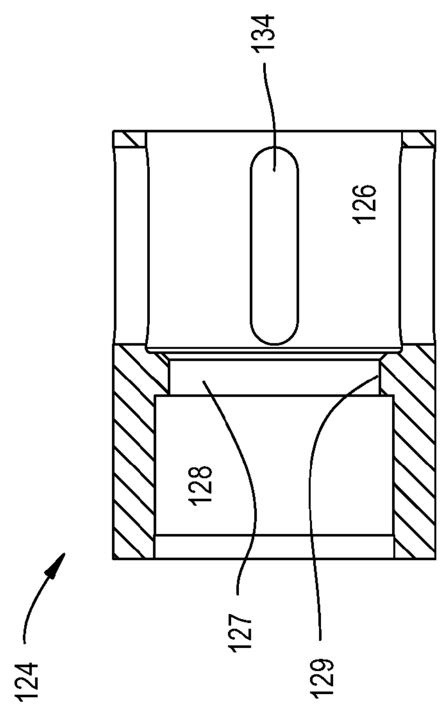
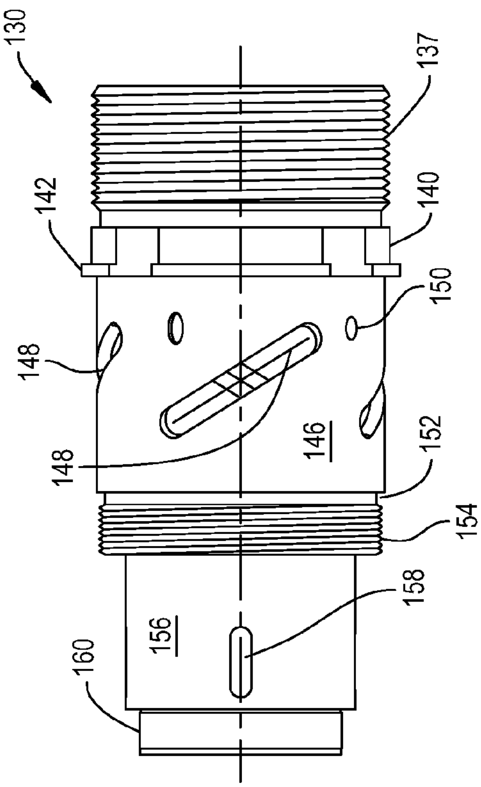



FIG. 9

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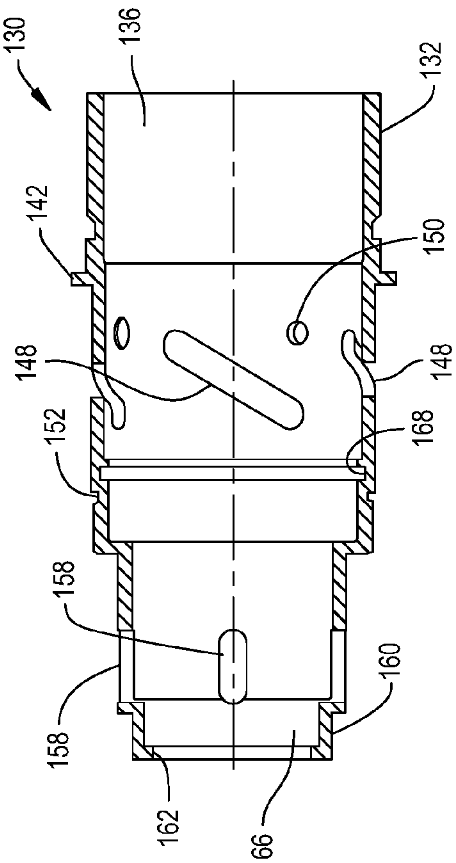
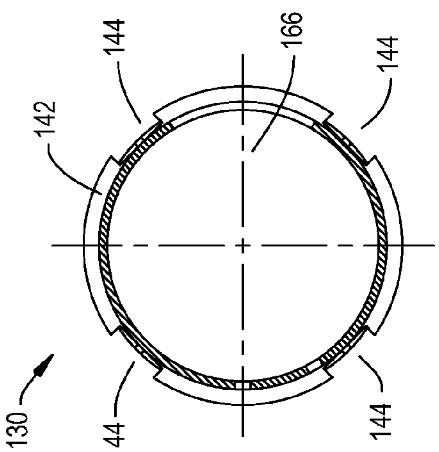



FIG. 12

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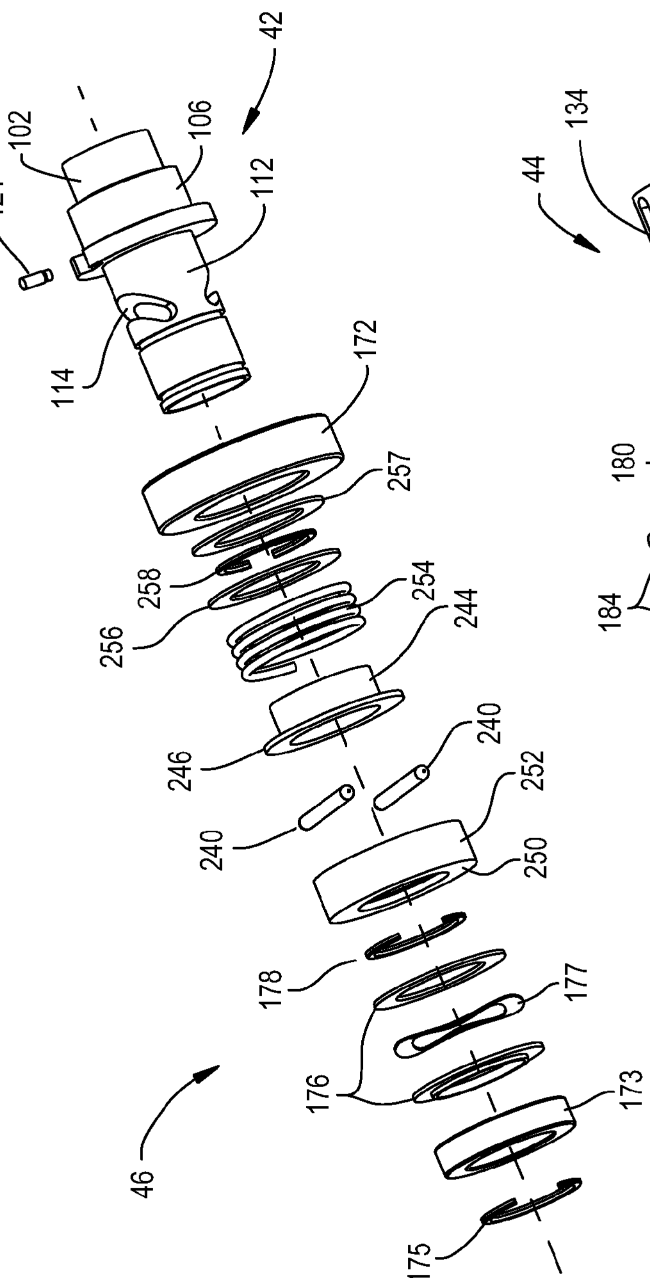
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FIG. 22

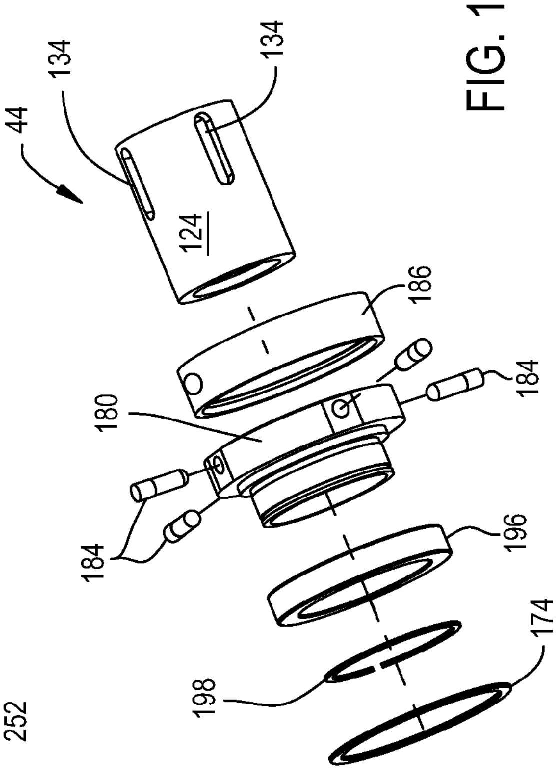
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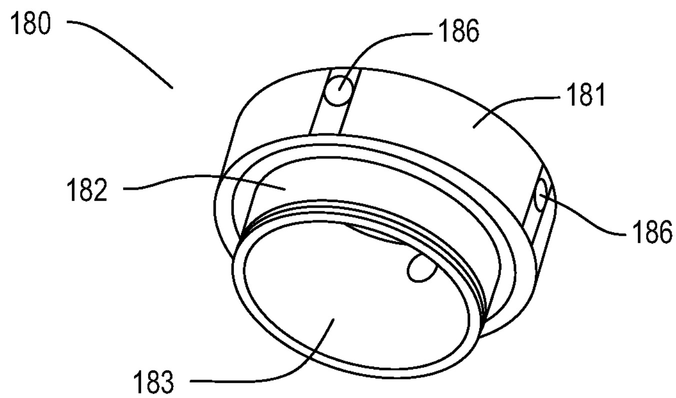
FIG. 13

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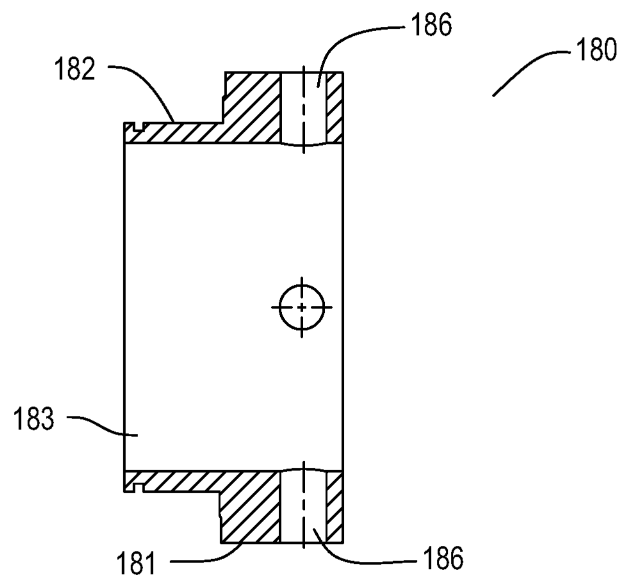


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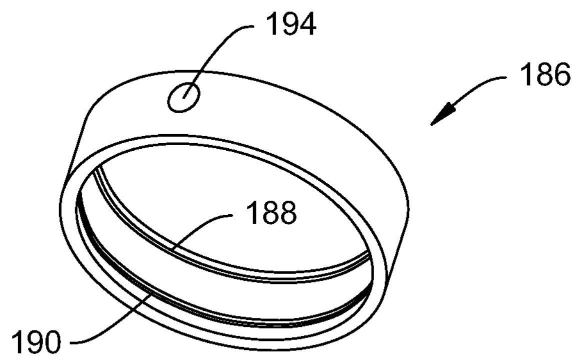


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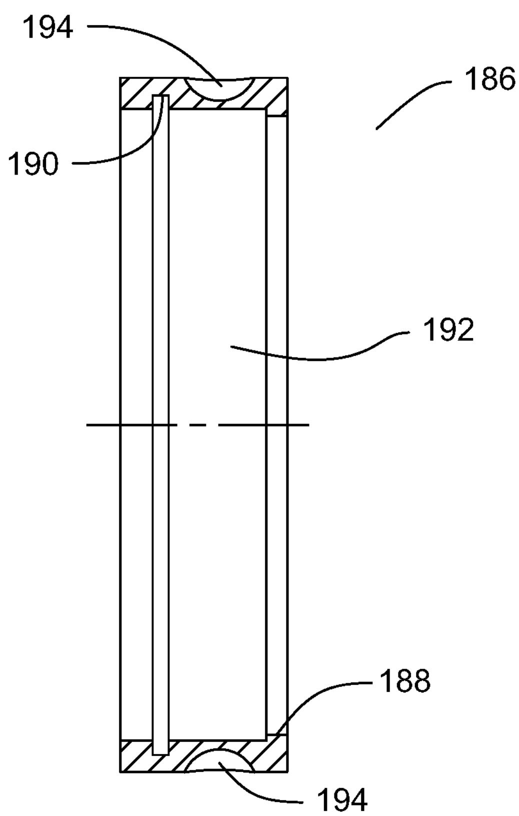


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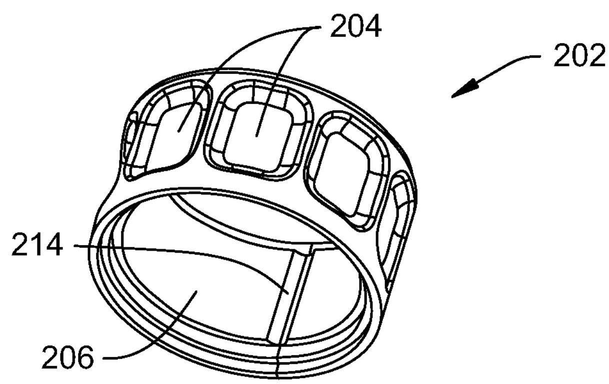


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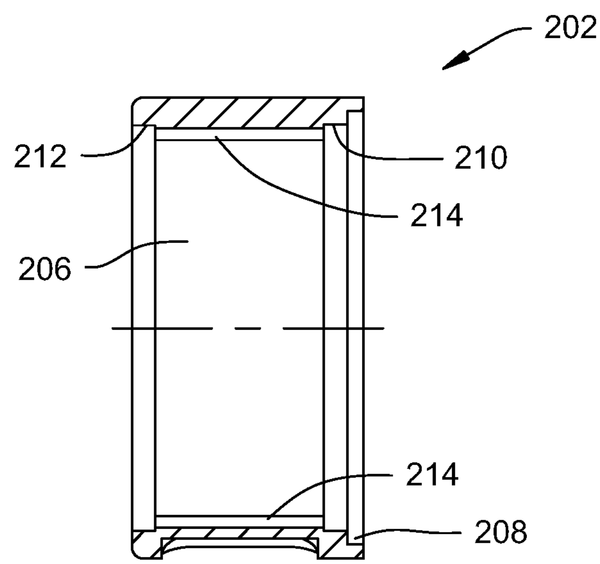


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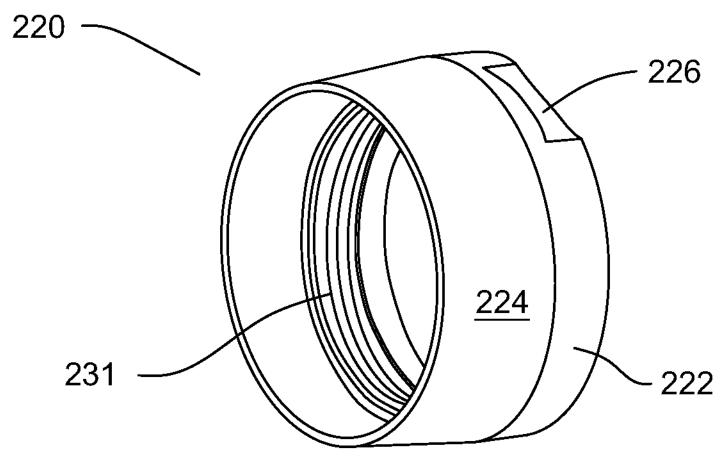



FIG. 20

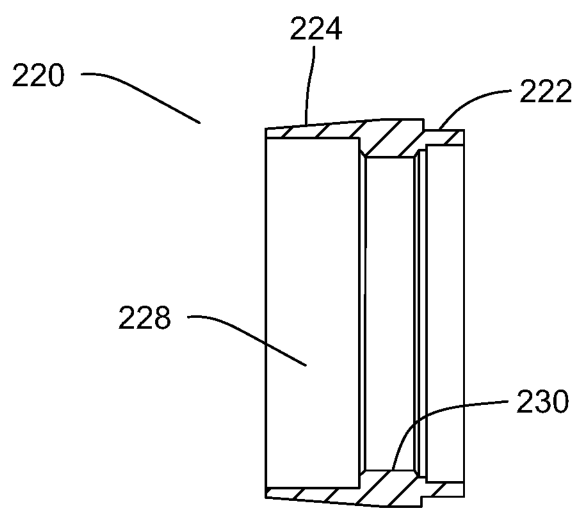
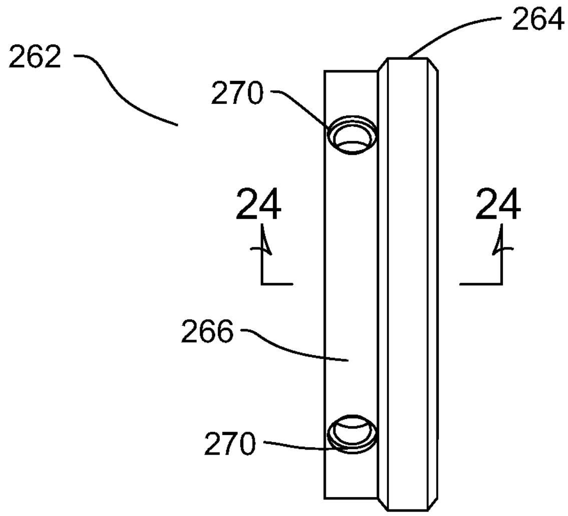



FIG. 21

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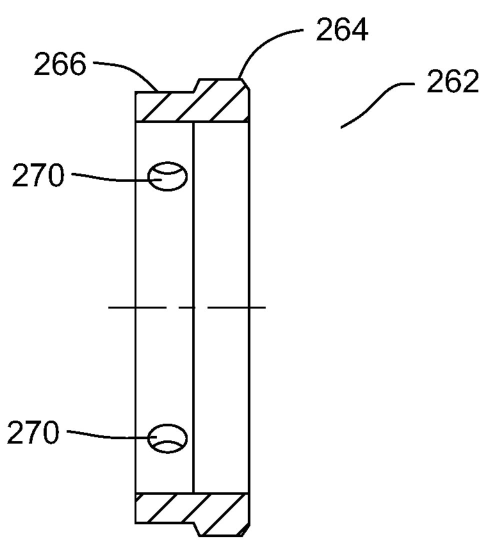


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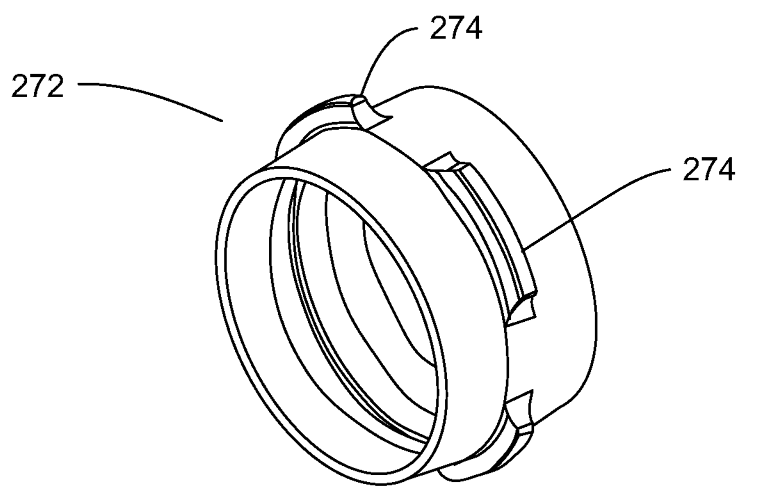


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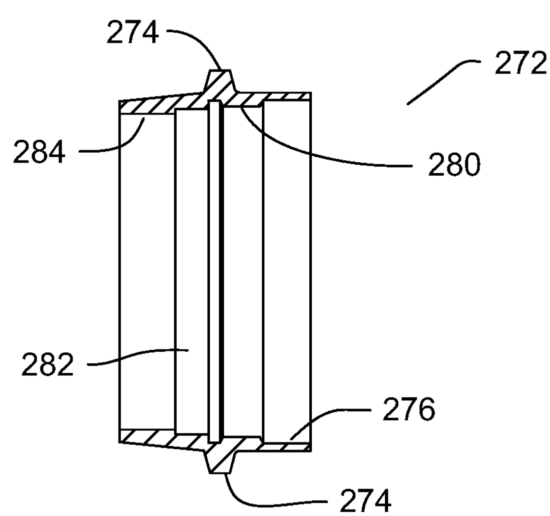


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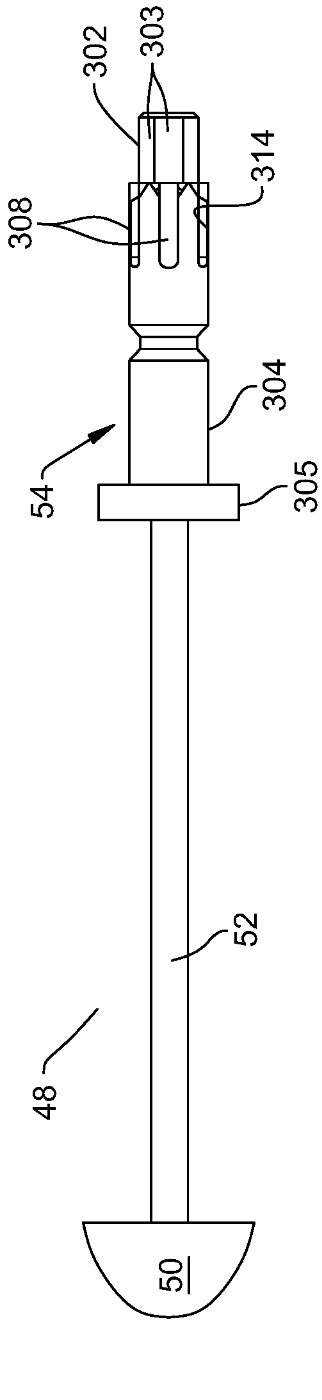


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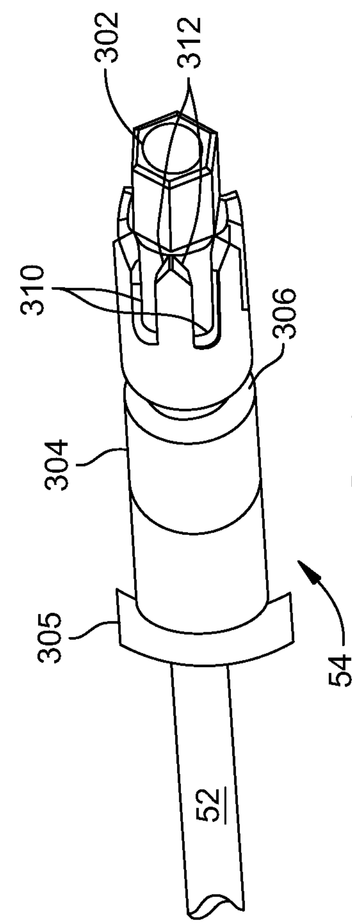



FIG. 27A

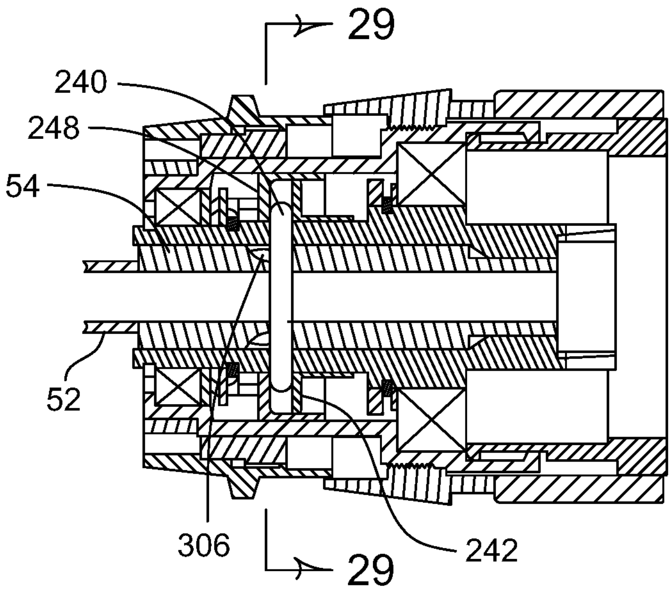



FIG. 28

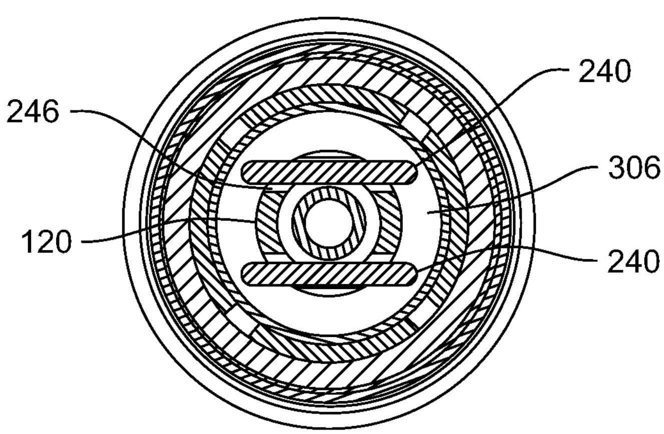



FIG. 29

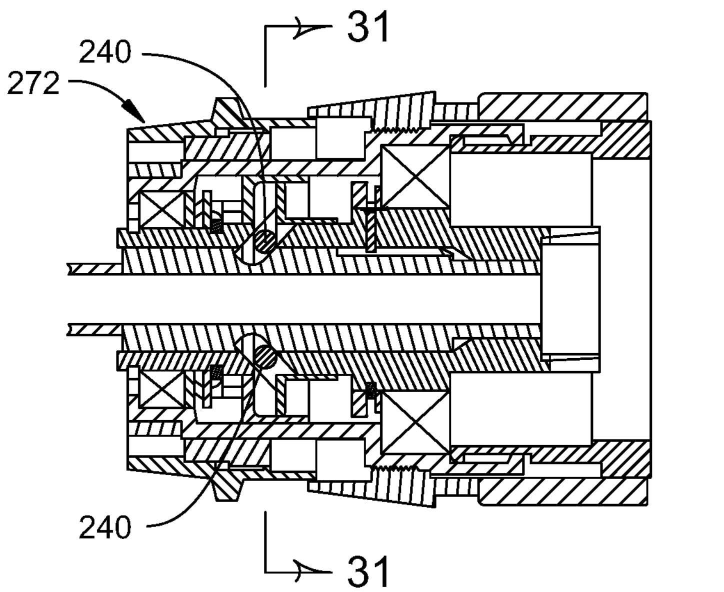
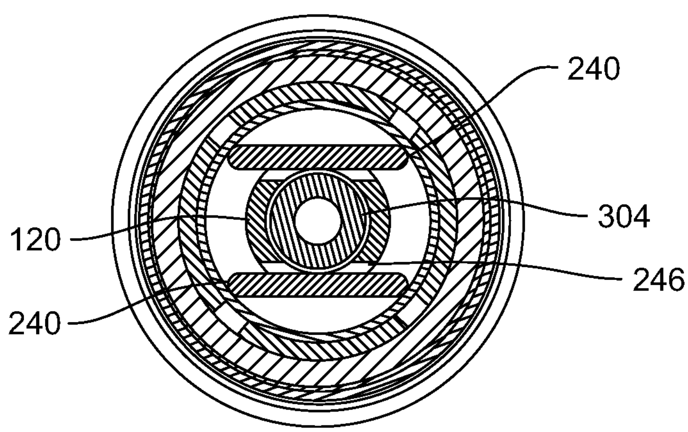



FIG. 30

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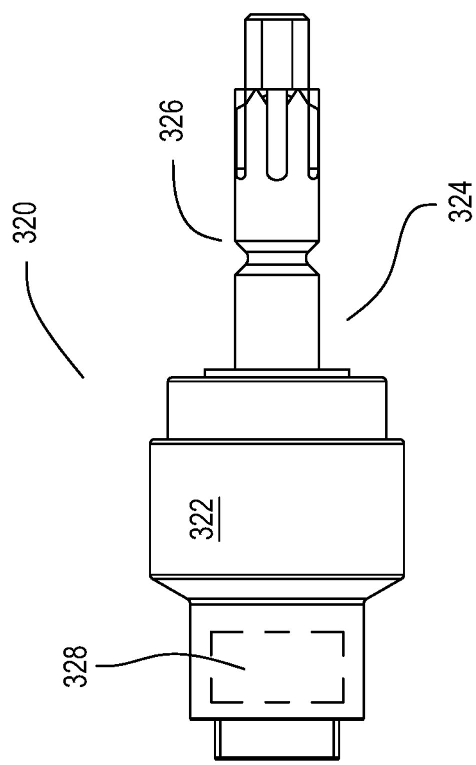


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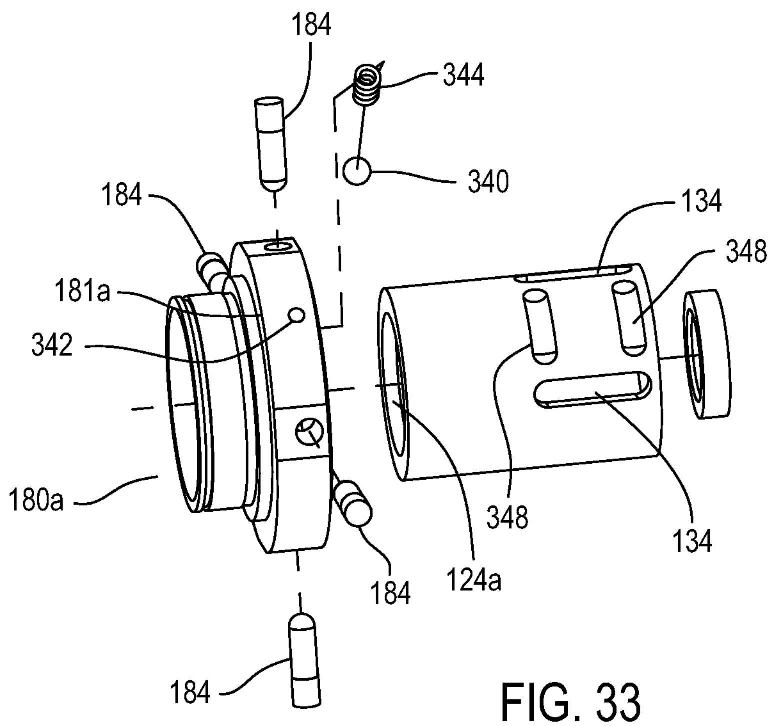
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FIG. 33

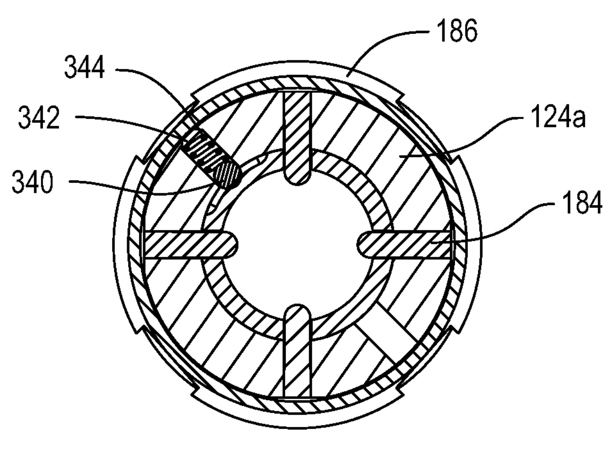
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FIG. 34

# SURGICAL HANDPIECE WITH A COMPACT CLUTCH

## RELATIONSHIP TO EARLIER FILED APPLICATION

This application claims priority from U.S. patent application Ser. No. 11/471,266 filed 20 Jun. 2006, now U.S. Pat. No. 8,419,760. Application Ser. No. 11/471,266 claims priority under 35 U.S.C. Sec. 119 from U.S. Provisional Pat. App. No. 60/693,638 filed 25 Jun. 2005. Both priority applications are incorporated herein by reference.

## FIELD OF THE INVENTION

This invention relates to a surgical handpiece able to accept different rotating attachments and cutting accessories. More particularly, this invention is related to a surgical handpiece with a clutch for transferring rotational moment from a drive assembly that is compact in size. This invention is further related to a surgical handpiece with a coupling head for receiving different attachments or accessories that minimizes attachment/accessory rotational wobble.

## BACKGROUND OF THE INVENTION

In modern surgery, an important instrument available to medical personnel is the powered surgical tool. Often, this tool is a handpiece in which a motor is housed. Secured to the handpiece is a cutting accessory designed for application to a surgical site on a patient in order to accomplish a specific medical task. Some powered surgical handpieces are provided with drills or reamers for cutting bores or other void spaces in tissue. The ability to use powered surgical tools on a patient lessens the physical strain of surgeons and other medical personnel when performing procedures on a patient. Moreover, most surgical procedures can be performed more quickly, and more accurately, with powered surgical tools than with the manual equivalents that preceded them.

One such type of tool is the surgical rotary handpiece. A rotary handpiece has spindle that rotates in response to actuation of the handpiece motor. Attached to the front end of the spindle is a coupling assembly. The coupling assembly releasably holds a device to the spindle so that the device rotates in unison with the spindle. Generally, two types of devices are releasably coupled to a handpiece spindle. One type of device is the actual cutting accessory, for example, the drill or the reamer. The cutting accessory has a shaft. The proximal end, the rear end, of the shaft is releasably held to the spindle by the coupling head.

The second type of device coupled to a rotary handpiece is a front end attachment. The attachment has a housing with opposed front and rear ends. An input shaft extends from the attachment rear end. The attachment front end has its own output spindle and complementary coupling assembly. Sometimes a gear assembly is located between the input shaft and the output spindle of an attachment. The gear assembly contains gears that typically increase the torque/decrease the speed of the rotational motion applied to the attached cutting accessory through the attachment output spindle. When the attachment is attached to the handpiece, the attachment housing is often statically coupled to the handpiece housing. The handpiece coupling assembly holds the attachment input shaft to the handpiece spindle. The actual cutting accessory is locked to the attachment spindle. The attachment speed reduces or speed increases the rotational moment output by the handpiece that is applied to the cutting accessory. Typically an attachment is used to speed reduce/torque increase the rotational moment of the attached cutting accessory.



Other attachments provide a means to attaching a cutting accessory to the handpiece spindle so the two components rotate at the same speed. An attachment of this variety typically does not have a gear assembly.

It is known to provide surgical handpieces with internal torque increasing/speed reducing gear assemblies. Some of these assemblies have plural output heads. This gear assembly receives the rotational moment from the motor output shaft and simultaneously rotates the plural output heads at different speeds. A clutch selectively connects the drill output spindle for rotation to one of the gear assembly output heads. The output speed/torque producing capability of the handpiece spindle is set by setting the clutch to selectively set the gear assembly-to-drill spindle connection. In some circumstances, these assemblies eliminate the need to employ a front head torque increasing/speed reducing attachment.

Known handpiece gear and clutch assemblies are relatively long in length. A disadvantage of this type of structure is that it increases the overall length of the handpiece. This runs contrary to a goal of efficient handpiece design, namely, the handpiece should be made as short as possible. This is because it easier for a surgeon to accurately position the working end of the cutting accessory that is relatively close to his/her hand than one further away. To provide this feature it is, therefore, desirable to construct a handpiece that has an overall length, especially from the motor forward, that is as compact as possible.

Moreover, a surgical handpiece is typically designed to be held at or near its center of gravity. This design reduces the physical stress to which the surgeon is exposed when he/she holds and needs to precisely position the tool in order to accomplish a given surgical procedure. The positioning of any mass away from a surgical handpiece's center of gravity/hand hold makes it more difficult for the surgeon to hold and precisely position the handpiece. Known gear and clutch assemblies, because of their lengths and masses, are typically off center from the center of gravity of the handpieces with which they are integral. During a surgical procedure, it may be necessary for the surgeon to precisely control a tool's position for an extended period. The off-center mass of a gear and clutch assembly can add to the physical stress to which the surgeon is exposed when so holding the tool.

Other disadvantages are associated with known coupling assemblies used to releasably hold cutting accessories and attachments to the handpiece spindles. Known coupling assemblies are effective for transmitting torque, rotational moment, from a handpiece spindle to the attached accessory/attachment and hold the accessory/attachment firmly to the spindle. Nevertheless, many coupling assemblies allow that shaft of the attached accessory/attachment to radially shift position, relative to the axis of the associated handpiece spindle.

The looseness of this fit allows the accessory/attachment to wobble when coupled to the handpiece. Wobble present in the shaft adjacent the surgical handpiece is amplified at the distal free end of the attachment, the end applied to the surgical site. Some attachments, for example reamers and drills used to perform certain procedures have lengths of 10 cm or more. The wobble, the radial shifting, at the distal end of these attachments can therefore be quite significant. The presence of this movement can appreciably add to the overall control the surgeon must exert in order to ensure that the working end of the attachment remains accurately position at the surgical site to which the attachment is applied.

## SUMMARY OF THE INVENTION

This invention is related to a new and useful surgical rotary handpiece. The handpiece of this invention has both a clutch assembly that is compact in length and a coupling assembly that limits the wobble of the shaft of the complementary accessory/attachment fitted to the handpiece.

The clutch of the surgical rotary handpiece of this invention has moveable pins that selectively connect one of a plurality of the gear assembly drive heads to the handpiece output spindle for simultaneous rotation. A shifter positions the movable pins. A shift ring displaces the shifter. The moveable pins and members that transfer the motion from the shift ring to the shifter overlap. Collectively, these features combine to form a clutch of short axial length.

The coupling assembly of the handpiece of this invention is partially integral with the handpiece spindle. Internal to the spindle is a bore in which a coupling head of the attachment/accessory shaft is seated. The most proximal end of the surfaces of the spindle that define the bore and the most distal end of the coupling head are formed with complementary geometric features that force the transfer of torque, rotation movement, from the spindle to the shaft.

Extending forward, the coupling head is formed with a stabilizing body. This spindle bore is shaped so that the body is tightly fitted in the adjacent section of the bore. In some preferred versions of the invention, the stabilizing body and complementary bore-defining shaft inner wall have circular cross sectional profiles. Owing to the tight fit of the shaft in the bore, wobble of the shaft is minimized.

The accessory/attachment stabilizing body is formed with an indentation. In one version of the invention, this indentation is an annular groove that extends around the stabilizing body. The coupling assembly has retractable pins that extend into the spindle bore. The pins seat in the complementary stabilizing body indentation to releasably lock the accessory/attachment to the housing spindle.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention is pointed out with particularity in the claims. The above and further features of this invention may be better understood by reference to the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a side view of a surgical rotary handpiece of this invention to which a surgical accessory of this invention is attached;

FIG. **2** is a cross sectional view of the front end of the handpiece along the longitudinal axis;

FIG. **2**A is an enlarged cross sectional view of the distal end of the handpiece of FIG. **2**;

FIG. **3** is an exploded view of the distal front end of the handpiece;

FIG. **4** is an exploded view of the gear train of the surgical handpiece of this invention;

FIG. **5** is a cross sectional view of the gear train;

FIG. **6** is a plan view of the spindle of the surgical handpiece of this invention;

FIG. **7** is a cross sectional view of the spindle taken along line **7-7** of FIG. **6**;

FIG. **8** is a perspective view of the output coupler;

FIG. **9** is a cross sectional view of the output coupler;

FIG. **10** is an end view of a rotary housing of the surgical handpiece of this invention;

FIG. **11** is a plan view of the rotary housing;

FIG. **12** is a cross section view of the rotary housing taken along line **12-12** of FIG. **11**;

FIG. **13** is an exploded view of the components forming the clutch;

FIG. **14** is a perspective view of the inner shifter of the clutch of this invention;

FIG. **15** is a cross sectional view of the inner shifter;

FIG. **16** is a perspective view of the shifter housing;

FIG. **17** is a cross sectional view of the shifter housing;

FIG. **18** is a perspective view of the shift ring;

FIG. **19** is a cross sectional view of the shift ring;

FIG. **20** is a perspective view of the shift ring nut;

FIG. **21** is a cross sectional view of the shift ring nut;

FIG. **22** is an exploded view of the coupling assembly;

FIG. **23** is a side view of the coupling assembly actuating ring;

FIG. **24** is a cross sectional view of the actuating ring;

FIG. **25** is a perspective view of the actuating sleeve;

FIG. **26** is a cross sectional view of the actuating sleeve;

FIG. **27** is a plan view of a cutting accessory with the coupling head of this invention;

FIG. **27**A is a perspective view of the coupling head of the cutting accessory;

FIG. **28** depicts how a coupling assembly pin seats in a groove of the coupling head according to this invention;

FIG. **29** is a lateral cross section view illustrating how the coupling assembly pins seat in the coupling head indentation;

FIG. **30** is a cross sectional view illustrating the position of the coupling assembly when in the load state;

FIG. **31** is a lateral cross section view illustrating the position of the coupling assembly pins when in the load state;

FIG. **32** is a plan view of an attachment with the coupling head of this invention;

FIG. **33** is an exploded view of a section of an alternative clutch assembly of this invention; and

FIG. **34** is a cross sectional view of a portion of the assembly of FIG. **33**.

## DETAILED DESCRIPTION

FIGS. **1** and **2** illustrate a rotary surgical handpiece **20** constructed in accordance with the invention. Handpiece **20** has a housing **22** in which in a motor **24** is seated. In one version of the handpiece **20**, motor **24** is a DC motor. In other versions of the invention, motor **24** may be an AC motor, or a pneumatic or hydraulically driven motor. Integral with the motor **24** is rotating output shaft **26**. Handpiece housing **22** is shaped to have a generally cylindrical head **28** in which motor **24** is fitted. Extending downwardly from head **28**, handpiece housing **22** is shaped to have a handle **30** generally in the form of a pistol grip.

At least one trigger switch **32** extends distally forward from the front face of handle **30**. ("Distal", it shall be understood means toward the surgical site to which the handpiece **20** is directed. "Proximal", means away from the surgical site.) A control circuit internal to the housing **22**, (not illustrated and not part of this invention) monitors the actuation of the trigger switch **32**. Based on the extent to which the trigger switch **32** is actuated, the control circuit selectively energizes the motor **24** to cause the output shaft to rotate at the desired speed.

A gear train **36** is connected to the exposed distally located front end of the motor shaft **26**. Gear train **36** includes gears that reduce the speed and increase the torque of the rotational moment output by shaft **26**. The gear train **36** has two rotating drive heads **86** and **92** (FIG. **4**). Owing to the arrangement of the gears forming gear train **36**, the rotation of motor shaft **26** causes drive heads **86** and **92** to simultaneously rotate at different speeds. Gear train **36** thus functions as a speed reduction assembly that outputs rotational force at two separate speeds.

With reference to FIGS. **2**, **2**A and **3** it can be seen that a spindle **42** is rotatably mounted to the housing head **28** forward of gear train **36**. A clutch **44** selectively connects one of the two gear train drive heads **86** or **92** to spindle **42** so that the spindle and connected drive head rotate in unison.

A coupling assembly **46** releasably holds a surgical attachment or a surgical cutting accessory **48**, seen in FIG. **27** to the spindle **42**. The particular cutting accessory **48** is an accetabular reamer. Again, it should be appreciated that this is exemplary, not limiting. Cutting accessory **48** has a distal end tissue working head **50**, in the example, an accetabular reamer head. Extending proximally from tissue working head **50**, cutting accessory **48** has an elongated shaft **52**. A coupling head **54** is attached to the proximal end of shaft **52**. Coupling head **54** is formed with geometric features that facilitate the rotational coupling of cutting accessory **48** to spindle **42** and minimize wobble of the accessory relative to the handpiece **30**.

Surgical handpiece **20** of this invention is constructed so that the distal end of spindle **42** is formed with a bore **120** (FIG. **7**) for receiving the attachment/accessory coupling head **54**. Coupling assembly **46** locks the accessory coupling head **54** in spindle bore **120**. As a consequence of this engagement, the coupling head **54**, and therefore the whole of cutting accessory **48**, rotates in unison with the spindle **42**.

Gear train **36**, now described by reference to FIGS. **3-5**, includes a first set of three (3) planet gears **62** (two shown). Planet gears **62** are each rotatably mounted to a generally disc shaped planet carrier **64**. Planet gears **62** and planet carrier **64**, as with the remaining planet gears and planet carriers of gear train **36** are housed in a generally tubularly shaped ring gear **66**. Ring gear **66** has a smoothed shaped outer wall and a toothed inner wall, (teeth not illustrated). The teeth of planet gears **62**, as well as the teeth of the remaining planet gears **74** and **82**, engage the teeth of ring gear **66**.

Ring gear **66** is statically mounted in the handpiece housing head **28** forward of motor **24**. To facilitate the static mounting of ring gear **66**, the ring gear is formed with two proximally extending feet **68**. The feet seat in openings formed in an internal structural web **70** of the housing to block rotation of the ring gear (openings not identified).

Planet gears **62** seat over and engage a gear pinion **71** disposed over motor shaft **26** (identified in FIG. **2**). Thus, the rotation of motor shaft **26** results in the rotation of planet gears **62** and planet carrier **64**.

A first sun gear **72** is integrally mounted to, concentric with and extends distally forward from planet carrier **64**. Sun gear **72** engages a second set of three (3) planet gears **74** (two shown). Planet gears **74** are rotatably disposed around a second planet carrier **76**. A tubular post **78** is integrally attached, concentric with and extends distally forward from second planet carrier **76**. A set of teeth disposed around the proximal end base of post **78** form a second sun gear **80**.

Second sun gear **80** engages a third set of planet gears, four (4) planet gears **82** (one shown). Planet gears **82** are rotatably attached to and disposed around a third planet carrier **84**. A first drive head **86** is formed integrally with and extends axially forward from the third planet carrier. The first drive head **86** has a generally circular outer profile. The outer surface of drive head **86** is further shaped to have a plurality of longitudinally extending inwardly concaved, notches **88**. The notches **88**, which are circumferentially spaced apart, are located around the whole of the circumference of drive head **86**. Planet carrier **84** is further formed to have an axially extending through bore **90**. Bore **90** extends completely through both the planet carrier **84** and drive head **86**.

A second drive head, drive head **92**, is positioned distally forward of and is concentric with drive head **86**. Drive head **92** has the same outer diameter as drive head **86**. Drive head **92** is further shaped to notches **94** that have the same profile of notches **88** of the first drive head **86**. A tubularly shaped stem **96** extends proximally rearward from drive head **92**. In many versions of the invention, second drive head **92** and stem **96** are integrally formed. When gear train **36** is assembled, post **78** of the second planet carrier **76** is disposed in bore **90** of third planet carrier **84** and drive head **86**. Stem **96** similarly is disposed in bore **90**. More particularly, stem **96** is dimensioned to be tightly press fit over post **78**. Thus, drive head **92** rotates in unison with the second planet carrier **76**. Collectively, post **78** and stem **96** are shaped so that there is a longitudinal separation between drive heads **86** and **92**.

Drive head **86** and stem **96** are further collectively shaped so that the outer surface of the stem is spaced inwardly of the adjacent bore **90** defining inner wall of the drive head. This arrangement allows stem **96** to rotate freely relative to the drive head **88**. Adjacent the proximal end of stem **96**, a bearing assembly **97** extends between post **78** and an adjacent inner circular wall internal to planet carrier **84**. More particularly, the planet carrier internal wall against which the outer race of bearing assembly **97** seats defines an elongated groove **99** that is concentric with and has a large outer diameter than planet carrier bore **90**. A retaining ring **100** disposed proximal to the bearing assembly **97** holds the bearing assembly in position. Retaining ring **100** is snap fitted in a groove **101** also formed in the interior of planet carrier **84**. The planet carrier **84** is formed so that groove **101** is between the proximal end opening of bore **90** and groove **99** and is of greater diameter than groove **99**.

Drive head **92** has a nose **91**. Nose **91** extends forward of the portion of the drive head formed with notches **94**. An O-ring **89** is disposed over nose **91**. O-ring **89** is fitted over the drive head nose **91** portion immediately distal to the portion of the nose that defines notches **94**.

A bearing assembly **95** rotatably holds planet carrier **84** to the static ring gear **66**. Bearing assembly **95** has an outer race (not illustrated) seated in the perimeter of a counterbore **67** that forms the open end of ring gear **66**. The inner race of bearing assembly **95** (not illustrated) seats against an annular step **98** formed in the outer perimeter of the third planet carrier **84**. A retaining ring **87** holds bearing assembly **95** and, by extension, the moving components of gear train **36**, in ring gear **66**. Retaining ring **87** is snap fitted in a groove **93** formed in the inner wall of the ring gear **66** that defines counterbore **67**.

The structure of the spindle **42** is now described by reference to FIGS. **6** and **7**. Generally, spindle **42** is formed from a single piece of metal that has circular sections of different diameters. At the most proximal end, spindle **42** has a head **102**. Spindle **42** is further formed so that, internal to head **102** is a bore **104** with a hexagonal cross-sectional profile. The specific cross-section profile of bore **104** is not relevant to the basic structure of this invention. What is relevant is that bore **104** is shaped to closely slip fit receive the proximal end of the cutting accessory coupling head **54** fitted to the cutting accessory **48**. The close fitting is required because the inner surfaces of the spindle **42**, face surfaces **105**, that define bore **104** are the surfaces that transmit the torque to the cutting accessory **48**.

Extending distally from head **102**, spindle **42** has a collar **106**. Collar **106** is shaped to have an outer diameter greater than that of head **102**. Immediately forward, proximal, of the distal end of the collar **106**, the collar is shaped to have a groove **108** that extends circumferentially around the outer surface of the collar. Collar **106** is further formed to define an opening **110** that extends laterally through the collar. Opening **110** is located to extend through an arcuate section of the collar **106** that defines the base of groove **108**. Opening **110** extends from a base of a recess **111** cut into the outer surface of collar **106**.

Spindle **42** is further formed to have a stem **112** that projects distally forward from collar **106**. Stem **112** has a number of sections with different outer diameters. A proximal section **113** adjacent collar **106** has a diameter approximately equal to that of sleeve head **102**. Stem section **113** is formed to have two diametrically opposed receiving slots **114**. Each receiving slot **114** is in a plane that, relative to the longitudinal axis of spindle **42**, extends diagonally forward. In some versions of the invention, each slot **114** is in a plane that, relative to the longitudinal axis of the spindle **42**, is at an angle of approximately 45°. Thus, as seen in FIG. **6**, when viewing a slot **114** from the front, a slot **114** appears to have a curved profile.

Forward of section **113**, the stem **112** is further formed to have a circumferential groove **116**. Forward of groove **116** stem **112** has an intermediate section **115**. Section **115** has a diameter slightly less than that of proximal section **113**. The reduced diameter of stem section **115** allows below discussed wave spring **177** (FIG. **22**) to freely flex.

Forward of section **115**, spindle stem **112** is formed with a distal end section **117**. Stem section **117** has an outer diameter between the diameters of sections **113** and **115**. The inner race of a bearing assembly **173** (FIG. **2**A) tightly fits over stem section **117**. A groove **118** extends circumferentially around the outer surface of stem **112**. Groove **118** is located immediately proximal to the distal end of stem section **117**, which is also the distal end of spindle **42**.

Spindle **42** is further formed to have a bore **120** that extends from the distal end, through stem **112** and collar **106** to bore **104**. Bore **120** is concentric and contiguous with bore **104**. In preferred versions of the invention, bore **120** has a circular cross sectional profile, though that need not always be the case. Bore **120** is dimensioned to facilitate the close slip fitting of a coupling head **54** of the cutting accessory **48** as discussed below.

A pin **121**, seen in FIG. **13**, is fitted in spindle opening **110** so as to be directed to the longitudinal center axis of the spindle **42**. Pin **121** extends into bore **120**

A generally tubular shaped outer coupler **124** is tightly fitted to the spindle **42**, now described by reference to FIGS. **8** and **9**. Outer coupler **124** has a constant outer diameter. The outer coupler **124** is further formed to have a proximal end bore **126** that extends distally forward from the proximal end of the coupler. In one version of the invention, proximal end bore **126** extends approximately half way through the length of the coupler. Output coupler **124** also has a distal end bore **128** that extends rearward from the distal end of the coupler. Distal end bore **128** has a diameter that facilitates the compression fitting of sleeve head **102** in the bore **128**.

Between the proximal end and distal end bores **126** and **128**, respectively, output coupler **124** is formed to have a circular void space **127**. The outer perimeter of void space **127** is defined by a circular flange **129** that extends inwardly from the inner walls of coupler **124** that define bores **126** and **128** and space **127**. The distally-directed laterally extend annular face of flange **129** is the surface against which the



proximally directed face of sleeve head **102** abuts. Outer coupler **124** is further formed to have four longitudinally extending slots **134**. Each slot **134** extends from the outer surface of the coupler **124** into the proximal end bore **126**. Slots **134** are equangularly spaced apart from each other around the perimeter of the outer coupler **124**.

Outer coupler **124** itself is shaped to have an outer diameter that is slightly greater than the outer diameter of spindle collar **106**. When the spindle head **102** is fit in the outer coupler **124**, the distal end face of the outer coupler forms an annular step around the proximal end of the spindle collar **106**.

Returning to FIG. **2**, it can be seen that, when surgical handpiece **20** of this invention is assembled, the spindle **42** and outer coupler **124** sub-assembly are fitted in the housing **32** so that gear train drive heads **86** and **92** are disposed in the proximal end bore **126** of the outer coupler. Outer coupler **124** is shaped so that the inner wall that defines the proximal end bore **126** is spaced away from the drive heads **86** and **92**. Drive head nose **91** seats in outer coupler void space **127**. O-ring **93** abuts the adjacent inner face of coupler flange **129**.

Gear train **36**, outer coupler **124** and spindle **42** are substantially disposed in a rotary housing **130** that extends distally forward from the front of handpiece housing **22**. The rotary housing **130**, now described by reference to FIGS. **10-12**, is formed from a single piece of metal that has a number of circular cross-sectional sections. The most proximal section of the rotary housing **130** is a base **132**. The outer surface of rotary section base **132** adjacent the proximal end of the rotary section is formed with threading **137** (seen in FIG. **11** only). Base **132** is formed with an open ended bore **136**. Bore **136** is dimensioned to facilitate the loose slip fitting of the base over gear train ring gear **66**. When handpiece **20** is assembled, base threading **137** engages complementary threading **138** formed around an inner wall of housing **28** (FIG. **2**). This threaded engagement holds rotary housing **130** to the handpiece housing **22**.

Extending distally of the threaded section, rotary housing base **132** is formed with a section **140** with a smooth outer wall. Forward of base section **140**, the rotary housing **130** has a flange **142** that extends radially outward of base **132**. Flange **142** is the structural component of the rotary housing **130** that stops proximal movement of the rotary housing when the housing is screw fitted to the handpiece housing **22**. Rotary housing **130** is further formed to define four slots **144** that extend through base section **140** and flange **142**. Slots **144** are equangularly spaced apart. The slots **144** function as spaces for receiving a fastening tool (not illustrated) used to screw secure the rotary housing **130** to the handpiece housing **22** during manufacture.

Forward of flange **142**, rotary housing **130** forms a clutch sleeve **146**. Clutch sleeve **146** has a diameter slightly less than that of base **132**. The clutch sleeve **146** is formed to have four equangularly spaced apart slots **148**. Slots **148** extend diagonally downwardly around the outer circumference of the clutch sleeve **146**. Four equangularly spaced apart holes **150** are also formed in the clutch sleeve **146**. Holes **150** are in a common circumferential section of the clutch sleeve located proximal to the proximal ends of slots **148**. Holes **150** are provided to facilitate manufacture and disassembly of the handpiece **20**.

A groove **152** is formed in the clutch sleeve **146** to extend circumferentially around the outer surface of the sleeve. Groove **152** is located proximally rearward of the forward distal end of the clutch sleeve **146**. The outer surface of the clutch sleeve **146** located distal to groove **152** and extending to the distal end of the clutch sleeve is provided with threading **154** (seen in FIG. **11** only).

Projecting distally forward of clutch sleeve **146**, rotary housing **130** has a coupling neck **156**. Coupling neck **156** has a diameter less than that of clutch sleeve **146**. The coupling neck **156** is formed to define four equangularly spaced apart slots **158**. Slots **158** extend longitudinally along the coupling neck **156** and are generally located in the most distal portion of the coupling neck **158**.

A head **160** forms the most distal section of rotary housing **130**. Head **160** extends forward from and has a diameter less than that of coupling neck **156**. Head **160** is formed with an inwardly directed circumferential lip **162**. Lip **162** defines the open distal end of the rotary housing, (distal end opening not identified).

Rotary housing **130** is further formed so that extending axially, distally forward from bore **136** there is a bore **166** that extends to the distal end of the housing. Bore **166** has sections of different diameters. The diameters of the different bore sections (not identified) are generally sized relative to each other in the same manner the outer diameters of the clutch sleeve **146** and coupling neck **156**, and head **160** correspond to each other. The rotary housing **130** is further formed to have a groove **168** that extends inwardly from a housing inner wall that defines one of the sections of bore **166**. Specifically, groove **168** is formed in the housing clutch sleeve **146** so as to be immediately distal to the circular slice of the sleeve **146** in which outer circumference groove **152** is formed.

Bearing assemblies **172** and **173**, seen best in FIGS. **2**A and **13**, rotatably hold the spindle and outer coupler sub-assembly to the rotary housing **130**. The outer race of bearing assembly **172** (outer race not illustrated) seats against the bore **166**-defining inner wall of the housing clutch sleeve **146**. The proximal end of the bearing race seats against the stepped inner annular surface of the rotary housing between the clutch sleeve **146** and the coupling neck **156**. The proximally-directed face of the outer race of bearing assembly **172** abuts a retaining ring **174** disposed in bore **166**. Retaining ring **174** is snap fitted in rotary housing groove **168**.

The inner race of bearing assembly **172** (not illustrated) is press fit over spindle collar **106**. When the handpiece **20** of this invention is assembled, the proximal end of the inner race of bearing assembly is disposed against the annular portion of the distally directed face of the adjacent outer coupler **124**. As discussed above, the outer race of bearing assembly **172** is blocked from distal movement by the adjacent inner walls of the rotary housing **130**. Thus, the abutment of the outer coupler **124** against the inner race of bearing assembly **172** by extension blocks distal movement of the spindle and outer coupler sub-assembly.

Bearing assembly **173** extends between the distal front end of spindle stem **112** and the adjacent inner wall of the rotary housing head **160**. The outer race of bearing assembly **173** (race not illustrated) seats against the inner wall of the rotary housing **130** within the housing head **160**. The bearing assembly outer race also abuts the proximally directed surface of rotary housing lip **162**. The distally directed face of the inner race of bearing assembly **173** seats against a retaining ring **175**. Retaining ring **175** is snap fitted into groove **118** of spindle stem **112**. Thus, collectively, rotary housing lip **162** and retaining ring **175** block forward movement of bearing assembly **173**.

Washers **176** and **177** and retaining ring **178** cooperate to prevent proximal movement of bearing assembly **173**. Two washers **176** are provided. The more distal of the two washers **176** is disposed against the proximally-directed face of the bearing assembly **173**. Washer **177**, which is flexible wave washer, is sandwiched between the distal and proximal washers **176**. The retaining ring **178** seats in spindle groove **116**. The retaining ring **178** extends above the outer surface of the surrounding spindle sleeve **112**. When handpiece **20** is assembled, the exposed portion of the retaining ring **178** blocks proximal movement of washers **176** and **177** and, therefore, similar movement of bearing assembly **173**. Wave washer **177** is provided to ensure that, in the event of manufacturing variations, the distal washer **176** is disposed against the bearing assembly **173**.

Washers **176** are L-shaped. The short vertical sections of the washers **176**, (not identified) are disposed around the outer surface of the spindle stem **112**. The washer **176** closest to bearing assembly **173** is positioned so its vertical section is against the inner race of the bearing assembly. This arrangement holds the washer **176** off the inner race of the bearing assembly **173**. The washer **176** adjacent retaining ring **178** is positioned so that its vertical section abuts the retaining ring.

When the spindle and outer coupler sub-assembly is so positioned, gear train drive heads **86** and **92** are both seated in the outer coupler proximal end bore **126**. Slots **134** are formed in the outer coupler **124** so as to extend over the drive heads **86** and **92**. Also, the components of this invention are dimensioned so that when the spindle **42** is seated in the rotary housing **130**, the most distal end of the spindle projects a slight distance forward of the surrounding distal end of the rotary housing.

The construction of the clutch **44** is now described by reference to FIGS. **2**A and **13**. The clutch includes a circular inner shifter **180** disposed inside the rotary housing clutch sleeve **146** over the outer coupler **124**. As best seen in FIGS. **14** and **15**, inner shifter has a proximal end base **181**. Extending distally forward from base **181**, the inner shifter **180** is shaped to have a head **182**. Head **182** has an outer diameter less than that of base **181**. A constant diameter bore **183** extends axially through the inner shifter **180** from the proximal end of base **181** to the distal end of head **182**.

Inner shifter **180** is shaped so that when the outer coupler **124** is seated in bore **183**, the shifter is able to move longitudinally along the length of the outer coupler. Clutch **44** includes four equangularly spaced apart torque pins **184** that extend radially inwardly from the inner shifter base **181**. Each torque pin **184** is seated in a laterally extending opening **185** formed in the inner shifter base **181**. Each torque pin **184** extends through an associated one of the outer coupler slots **134**. Torque pins **184** are of sufficient length so end tips of the pins can seat in notches **88** and **94** of, gear train drive heads **86** and **92**, respectively.

A shifter housing **186** disposed over the inner shifter **180** longitudinally moves the inner shifter **180** over the outer coupler **124**. The shifter housing **186**, now described by reference to FIGS. **16** and **17**, is generally in the form of a constant outer diameter, ring shaped structure. Shifter housing **186** is further formed to, at the proximal end, have an inwardly extending lip **188**. A groove **190** extends inwardly from the annular inner wall of the shifter housing **186** that defines the center opening **192** through the housing. Groove **190** is located proximal to the distal end face of the shifter housing **186**. The shifter housing **186** is further formed to define, on the outer surface, two diametrically opposed spherical indentations **194**.

Shifter housing **186** is disposed in the rotary housing clutch sleeve **146**. Inner shifter head **182** is positioned inside the shifter housing **186**. A bearing assembly **196** is disposed between the outer circumferential wall of the inner shifter head **182** and the adjacent inner wall of the shifter housing **186**. The proximal end of bearing assembly **196** abuts the adjacent distally-directed annular surface of the inner shifter base **181** that projects radially beyond head **182**. The outer perimeter of the distally directed face of bearing assembly **196** abuts a retaining ring **198** fitted to the shifter housing **186**. Specifically, retaining ring **198** is snap fitted in shifter housing groove **190**. Thus, the capture of the opposed ends of bearing assembly **196** by the inner shifter base **181** and retaining ring **198** lock the inner shifter **180** and shifter housing **186** together for longitudinal movement. Bearing assembly **196** allows the inner shifter **180** and shifter housing **186** to axially rotate relative to each other.

A shift ring **202** rotatably mounted over the rotary housing clutch sleeve **146** is manually actuated to set the longitudinal position of the shifter housing **186** and, by extension, the inner shifter **180**. Seen best in FIGS. **18** and **19**, the shifter ring **202** is generally in the form of a tubular member. Indentations **204** formed in the outer surface of the shifter ring **202** facilitate the finger grasping of the ring. The shifter ring **202** is further shaped to define an axially extending through bore **206**. Bore **206** is dimensioned to allow the shift ring **202** to rotate over the underlying rotary housing clutch sleeve **146**. At the proximal end, shifter ring defines a first counterbore **208** that defines the proximal end opening into bore **206**. A second counterbore **210** is located between the first counter bore **208** and bore **206**. The second counterbore **210** has a diameter between that of bore **206** and counterbore **208**.

At the distal end, shift ring **202** is formed to have a third counterbore **212**. The third counterbore **212** forms the distal end opening into bore **206**. The second and third counterbores **210** and **212**, respectively, are of identical diameter. The inner wall of shift ring **202** that defines bore **206** is further formed to define two longitudinally extending, diametrically opposed concave grooves **214**. Each groove **214** extends from the second counterbore **210** to the third counterbore **212**.

When handpiece **20** of this invention is assembled, ball bearings **216** transfer the rotational motion of shift ring **202** into axial motion that displaces the shifter housing **186**. Each ball bearing **216** is seated in opposed ones of the rotary housing clutch sleeve slots **148**. Two ball bearings **216** are provided; there are four slots **148**. The additional slots **148** aid component orientation during assembly of the handpiece **20**. Inside the rotary sleeve **130**, each ball bearing **216** seats in a separate one of the indentations **194** formed in the shifter housing **186**. Outside of rotary housing **130**, each ball bearing **216** seats in a separate one of the grooves **214** formed in shift ring **202**.

When handpiece **20** of this invention is assembled, rotary housing flange **142** seats in the shift ring first counterbore **208**. O-rings **218** extend between the outer circumferential face of rotary housing **130** and the inner walls of shift ring **202**. A first O-ring **218** is seated in the annular space of shift ring second counterbore **210**. The second O-ring **218** is seated is seated in the shift ring third counterbore **212**. Both O-rings **218** extend over the smooth outer surface of the rotary housing clutch sleeve **146**.

A shift ring nut **220** holds the shift ring **202** to the rest of the handpiece **20**. Shift ring nut **220**, best seen in FIGS. **20** and **21**, is generally tubularly shaped. The shift ring **220** is formed to have a base **222** with a generally constant outer diameter. Forward of base **222** shift ring nut **220** has a head **224**. Extending distally forward, the outer diameter of the shift ring head **224** tapers inwardly. The shift ring **220** is further formed to define two opposed flats **226** in the proximal end of the outer surface of base **222**. Flats **226** receive a fastening tool used to screw secure the shift nut **220** to the rotary housing **130** during assembly.

Bore **228** extends axially through the shift ring nut **220** from the proximal end to the distal end. The shift ring is further formed to have an inwardly stepped annular lip **230** that extends inwardly from the inner circular wall that defines bore **228**. The inner round face of lip **230** is formed with threading **231** (seen in FIG. **20**). The shift ring nut **220** is screw secured to the rotary housing by engaging shift ring nut threading **231** with threading **154** on the rotary housing clutch sleeve **146**.

An understanding of the coupling assembly **46** of the surgical handpiece of this invention is now obtained by initial reference to FIGS. **2**A, **3** and **22**. Specifically, coupling assembly **46** includes two cylindrical retaining pins **240** each of which is seated in one of the spindle slots **114**. When pins **240** are in the most forward position in slots **114**, the pins seat in a groove (indentation) **306** formed in the coupling head **54** of the attachment/accessory attached to the handpiece **20**. Pins **240** thus hold the attachment/accessory to the tool spindle **42**.

An inner washer **242** and outer washer **248** are the components of coupling assembly **46** that releasably hold retaining pins in slots **114** and attachment/accessory indentation **306**. Inner washer **242** is shaped to have along any one slice thereof an L-shaped cross sectional profile. More specifically, the inner washer has cylindrical base **244** that extends over the spindle stem **112**. The spindle **42** and inner washer **242** are dimensioned relative to each other such that the inner washer can freely move longitudinally over the spindle. Inner washer **242** is further shaped to have a lip **246** that extends perpendicularly outwardly from the distal front end of base **244**.

Inner washer **242** nests in the outer washer **248**, also disposed over the spindle stem **112**. The outer washer is shaped to have flat, circularly shaped head **250**. Extending proximally rearwardly from the outer perimeter of the head **250** and formed integrally with the head is a cylindrically shaped skirt **252**. The outer washer **248** is positioned over the spindle stem **112** so that the washer head **250** is generally aligned with the distal ends of the spindle slots **114**. The distal end of the inner washer **242** is disposed in the annular space defined by the outer wall of the spindle stem **112** and the inner wall of skirt **252** of the outer washer **248**.

A coil spring **254** disposed around the spindle stem **112** normally urges the inner washer **242** towards the outer washer **248**. The proximal end of spring **254** seats against a washer **256** seated over the most distal portion of the spindle collar **106**. The proximally-directed face of washer **256** abuts a retaining ring **258**. Retaining ring **258** is snap fitted in spindle groove **108** and projects beyond the outer surface of the spindle collar **106**. The retaining ring **259** thus stops proximal movement of washer **256** and, by extension, spring **254**. A washer **257** is disposed between the proximally directed face of retaining ring **258** and the adjacent distally directed face of the inner race of bearing assembly **172**.

Spring **254** thus urges the inner washer **254** forward. This movement of the inner washer **254** first compression traps the retaining pins **240** trapped between the inner and outer washers **242** and **248**, respectively. The continued force imposed by the spring **254** continues to urge washers **242** and **248** and pins **240** forward. As a result of this forward movement of this sub assembly, pins **240** are held in a forward distal section of spindle slots **114**. The distal forward movement of this subassembly is stopped by the abutment of retaining pins **240** against the inner surfaces of the stem sleeve **112** that define the distal perimeters of slots **114**. When pins **240** are so positioned, each pin extends into spindle bore **120**.

An actuating ring **262** selectively moves washers **242** and **248** and, by extension, pins **240** away from the attachment/accessory indentation **306** in which they are seated. The actuating ring **262** extends circumferentially around the outer perimeter of the distal end of the rotary housing coupling neck

156. Now described in detail by reference to FIGS. 23 and 24, the actuating ring 262, which is generally ring shaped, is formed to have a proximal end base 264. The outer circumferential surface of the actuating ring base 264 is provided with threading, (not illustrated). Actuating ring 262 is further formed so that extending distally forward of base 264 there is a neck 266. Neck 266 has an outer diameter less than that of the base 264. The inner wall that defines the through bore through the actuating ring 262 (bore and inner wall not identified) is of a constant diameter along the length of the sleeve.

Four equangularly spaced apart pins 268 are mounted in radial openings 270 formed in the actuating ring neck 266. Pins 268 are directed inwardly towards the axial center of the actuating ring 262. When handpiece 20 of this invention is assembled, pins 268 extend through slots 158 formed in the rotary housing coupling neck 156. The seating of pins 268 in the rotary housing slots 158 limits the range of proximal and distal movement of the actuating ring 262. Pins 268 are of sufficient length that, when the actuating ring 262 is moved proximally rearward, the free ends of the pins press against the distally directed face of head 250 of the outer washer 248.

An actuator sleeve 272 functions as a handhold that allows the surgical personnel to move the actuating ring 262. As seen in FIGS. 25 and 26, the actuator sleeve 272 is formed so as to have along the outer surface thereof four spaced apart tabs 274. Tabs 274 function as finger holds that allow personnel to hold and rearwardly depress the actuator sleeve 272. In the sleeve of FIG. 1, a single circumferential lip 274*a* performs the same function as tabs 274.

The actuator sleeve 272 has an axially extending bore that extends completely through the sleeve. The bore has a first proximal end section 276. Forward of section 278 the bore has a second section 280. Section 280 has a diameter less than that of bore section 278. The inner wall of the actuator sleeve 272 that defines bore section 280 has threading, (not illustrated). Forward of bore section 280, actuating sleeve 272 is formed to have a bore section 282. (Between bore sections 280 and 282 there is a groove, not identified, present for manufacturing reasons.) Bore section 282 has an outer diameter less than that of bore section 280. Bore section 284, is the most distal section of the actuating sleeve through bore. Bore section 284 has a diameter less than that of bore section 282.

When the handpiece 20 is assembled, the actuator sleeve 272 is secured to and over the actuating ring 262. Specifically, the threaded surface that defines bore section 280 of the actuator sleeve 272 is screw secured to the threading on outer surface of the actuating ring base or ring base 264.

A coil spring 286 normally holds the actuating ring 262 distally forward, away from the outer washer 248. Spring 286 is disposed between the rotary housing coupling neck 156 and the shift ring nut 220. The proximal end of coil spring 282 seats against the outer annular step surface between the rotary housing coupling clutch sleeve 146 and the coupling neck 156. The distal end of spring 286 seats against the proximally directed face of the actuating ring base 264. Spring 286 urges actuating ring forward so as that pins 268 are normally spaced away from outer washer 248.

A torque ring 288 is press fit over the rotary housing head 160. Torque ring 288 is formed with two opposed laterally extending tabs 290. When the handpiece 20 is assembled the whole of the torque ring 290 is normally disposed in bore section 284 of the actuating sleeve 272. Torque ring 288 is shaped so that tabs 290 do not abut, and therefore do not restrict the movement of the actuating sleeve 272. When an attachment is fitted to handpiece 20, at least one torque ring tab may seat in a complementary notch formed in an exposed static component of the attachment. This engagement prevents the static elements of the attachment from rotating relative to the handpiece 20. In alternative versions of the invention, torque ring 288 has a single tab 290 or three or more tabs 290.

The cutting accessory 48 constructed in accordance with this invention is now described by reference to FIGS. 27 and 27A. The cutting accessory 48 has an elongated shaft 52. The coupling head 54 is integrally attached to the proximal end of the shaft 52. Coupling head 54 has the features that both receive the torque generated by the handpiece 20, facilitate the lock the cutting accessory 300 to the handpiece and inhibit the generation of accessory wobble.

The tissue working head 50 is attached to the distal end of the shaft 52. In the illustrated version of the invention, the tissue working head 50 is an accetabular reamer. It is understood that this is exemplary not limiting. In other versions of the invention, the tissue working head may be other members such as a drill head or a bur. Also, it should be understood that in some versions of the invention, the tissue working head may be releasably attached to the shaft 52. For example, a reamer head is often removably attached to the shaft 52 employed to rotate the reamer.

The coupling head 54, the most proximal end of the accessory 48, is formed to have three longitudinally spaced apart sections. The first, most proximal section of the coupling head 54 is a boss 302. Boss 302 is dimensioned to closely slip fit in spindle bore 104 and receive the torque output by the spindle 42. In the illustrated versions of the invention, bore 104 has a hexagonal cross sectional profile. Therefore, in this version of the invention, coupling head boss 302 has a hexagonal shape and is dimensioned to be of marginally smaller size than bore 104. The individual outer facial surfaces 303 of boss receive the torque that is transmitted by the complementary adjacent inner faces 105 of spindle 42.

The second, intermediate section of coupling head 54 is the body 304. Coupling head body 304 is shaped to closely slip fit in spindle bore 120. In the illustrated version of the invention, spindle bore 120 has a circular cross sectional shape. Coupling head body 304 has an identical circular cross section shape with a diameter marginally less than that of spindle bore 120. The coupling head body 304, it is further understood, occupies a cross sectional area greater than that occupied by the coupling head boss 302. The coupling head body 304 is further formed to have a groove 306 that extends circumferentially around the outer surface of the body. Groove 306 is positioned at approximately midway between the proximal and distal ends of the body. More particularly, groove 306 is positioned so that, when the coupling head 54 is seated in the handpiece spindle 42, the proximal surface of the head body 304 that defines the groove is approximately aligned with the proximal interior surfaces of spindle 42 that define spindle slots 114.

The proximal end of the coupling head body 304 is further formed to define a number of circumferentially spaced apart, slots 308. The base of each slot 308 is defined by a flat face 310 that is recessed relative to the surrounding curved outer surface of the rest of the coupling head body 304. Each face surface 310 is coplanar with and extends distally forward from a separate one of the faces forming the hexagonal coupling head boss 302. The proximal end sections of the portions of the coupling head 304 between slots 308 are formed with beveled faces 312. Each pair of beveled faces 312 meets at a point 314.

Shoulder 305 is the most distal section of the coupling head 54. The shoulder 305, which is contiguous with coupling head body 304, has a diameter greater than that of the body. In some versions of the invention, especially in coupling heads integral with an attachment **320** (FIG. **32**) as described below, shoulder **305** is physically separate from the rest of the coupling head **54**. In these versions of the invention, shoulder **305** is press fit over the associated shaft to rotate in unison with the shaft.

Surgical handpiece **20** of this invention is prepared for operation by inserting cutting accessory **48** into the handpiece spindle **42**. This process begins by the insertion of the cutting accessory coupling head **54** in spindle bore **120**. Eventually points **314** of the coupling head body **304** press against pins **240**. The manual force of this action is enough to overcome the opposite force imposed by spring **254**. Thus, the continued application of this force results in the pushing of pins **240** diagonally outwardly and rearwardly. Pins **240** thus ride up over the outer surface of the coupling head body **304**.

As coupling head **54** is continued to be inserted into the spindle **42**, one of the beveled faces **312** of the coupling head body **304** abuts spindle pin **121**. The continued insertion of the coupling head **54** results in the rotation of the coupling head until pin **121** seats in the body slot **308** with which the beveled face **312** is adjacent. This rotational movement of the coupling head **54** ensures that, as the coupling head is continued to be inserted into the spindle **42**, the coupling head boss **302** is aligned with and seats in the spindle bore **104**.

Once the accessory coupling head **52** is so seated, spring **254** pushes the sub-assembly of pins **240** and washers **242** and **248** forward. This movement results in the pins **240** moving diagonally forward in spindle slots **114**, toward the coaxial longitudinal center axes of the accessory coupling head **54** and the spindle bore **120**. This results in the seating of pins in coupling head groove **306**, as seen in FIGS. **28** and **29**. This seating of pins **240** in groove **306** latches coupling head **54** and, therefore, cutting accessory **48**, to the handpiece spindle **42**.

Clutch **44** is then set to couple the spindle **42** to one of the gear train drive heads **86** or **92** so that the spindle rotates with the selected drive head. Specifically, the clutch **44** is set so that torque pins **184** seat in the notches **88** or **94** of the drive head **86** or **92**, respectively, with which the spindle is to be connected. The setting, the longitudinal positioning of, the torque pins **184** is performed by rotating shift ring **202**. The rotation of shift ring **202** results in the helical movement of ball bearings **216** in rotary housing slots **148**. The longitudinal displacement of ball bearings **216** results in an identical longitudinal displacement of the shifter housing **186**. The longitudinal movement of the shifter housing **186** causes a like movement of the inner shifter **180**.

Since torque pins **184** are integral with inner shifter **180**, longitudinal displacement of the inner shifter results in the selective seating of the pins in either the notches **88** of the proximally located drive head **86** or notches **94** of the distally located drive head **92**.

Handpiece **20** of this invention is now ready for operating. The depression of trigger switch **32** results in the actuation of motor **24**. Motor shaft **26** rotates. Gear train **36** reduces the rotation moment output by shaft to two different speeds. Specifically, the gears internal to the gear train cause drive head **86** to rotate at a first reduced speed. Drive head **92** is caused to rotate at a second reduced speed less than the first reduced speed.

Depending on the setting of the clutch **44**, the torque pins **184** are seated in the notches **88** or **94** of one of the drive heads **86** or **92**, respectively. The torque pins **184** thus rotate at the speed of the drive head **86** or **92** with which the pins are engaged. The torque pins **184** extend through the outer coupler slots **134**. Consequently, the rotation of the torque pins results in a like movement of the outer coupler **124** and, therefore spindle **42**. Since the coupling head boss **302** is relatively closely fitted in the spindle bore **104**, and these components have non-circular cross sectional profiles, rotary motion of the spindle **42** is transferred by boss **302** to the coupling head **54** and the rest of the cutting accessory **48**.

When it is time to remove the cutting accessory **48**, actuator sleeve **272** is pushed rearwardly. This movement of the actuator sleeve **272** results in a diagonal rearward and outward movement of pins **240**. Pins **240** thus retract out of the coupling head groove **306** and spindle bore **120**, as seen in FIGS. **30** and **31**. This allows the cutting accessory **48** to be removed and a new accessory to be removably coupled to the handpiece **20**.

Clutch **44** of surgical handpiece **20** of this invention is constructed so that torque pins **184** directly transfer the rotational motion output by a drive head **86** or **92** directly to the spindle-outer coupler sub-assembly. Each clutch pin **184** extends laterally through the output coupler **124**, which is an extension of spindle **42**. Thus, the clutch pins **184** do not occupy a significant amount of longitudinal space. Also, the shifter housing indentations **194** in which ball bearings **216** are spaced relatively close to the clutch pins **184**. In some versions of this invention, the distance from the center of the indentions **194** to the center of the clutch pins is 2.0 cm or less. In more preferred versions of this invention this distance is 1.0 cm or less. Collectively, these features of the invention make it possible to provide an inner shifter and shifter housing assembly that has an overall length of 3.0 cm and, more preferably, 2.0 cm or less. In most preferred versions of this invention, the overall length of this sub-assembly is 1.0 cm or less.

Thus, the clutch **44** of this invention is relatively compact in length. This makes it possible to provide a handpiece with gear train and clutch assembly that likewise has a reduced axial length. Moreover, employing the clutch **44** of this invention reduces the extent to which the mass of components forming the handpiece **20** are distributed away from the center of gravity. By centering the component mass near the center line of the center of gravity, the stress to which a surgeon is exposed when precisely positioning the handpiece **20** is reduced.

When an attachment/cutting accessory coupling head is fitted to the spindle **42** of the handpiece of this invention, there is a relatively long and close interface between the inner wall of the spindle **42** that defines bore **120** and the outer surface of the coupling head body **304**. In some versions of this invention, this interface has a length of 0.6 inches or more. In more preferred versions of the invention, this interface has a length of 1.0 inches or more. This interface is located distal to where the spindle transfer torque to the coupling head boss **302**. This construction minimizes the wobble of the coupling head in the spindle when both components are rotated. The minimization of the coupling head wobble results in a like reduction of the wobble present at the cutting accessory tissue working head **50**.

Moreover, when coupling head **54** is fitted in spindle bore **120**, the coupling head shoulder **305** abuts the distal end opening of the spindle that defines the bore. Thus collectively, pins **240** and shoulder **305** prevent longitudinal wobble of the coupling head **54** in the spindle. Since the distal end of the rotating spindle **120** is spaced slightly forward of the static components of the handpiece **20**, the presence of shoulder **305** does not inhibit rotation of the cutting accessory **48**. To further ensure that there is no contact between the shoulder **305** and the static components of the handpiece **20**, the shoulder is dimensioned so it does not subtend area subtended by the static components. Thus, the outer diameter of shoulder **305** is less than the distal end opening into the rotary housing defined by lip **162**.

FIG. **32** illustrates an attachment **320** constructed in accordance with this invention. Attachment **320** includes a housing **322**. An input shaft **324** is extends rearwardly from the housing **322**. Input shaft is shaped to have a proximal end coupling head **326** with the same features as cutting accessory coupling head **54**. Internal to the housing is a coupling assembly **328** represented by a phantom rectangle. Coupling assembly **328** is designed to releasably hold the proximal end of a cutting accessory (not illustrated) for rotation. The exact structure of the coupling assembly **328** is not relevant to this invention. Coupling assembly **328** may include the features of coupling assembly **46**. Alternatively, coupling assembly **328** may be provided with features to hold coupling heads other than the described coupling head **54** for rotation. These include coupling heads with trinkle fittings, Hudson® fittings and modified trinkle fittings that are known in the surgical art.

Input shaft **324** rotates coupling assembly **328**. In some versions of the invention, input shaft **324** and the spindle of coupling assembly **328** are the same component. In these versions of the invention, attachment **320** thus serves as a means for connecting an accessory with a head different from coupling head **54** to the handpiece. In these versions of the invention, the attachment rotates at the speed at which the handpiece spindle **42** rotates. In other versions of the invention, there is a speed reducer or speed increaser gear assembly internal to the attachment housing **322** for transferring the rotational moment received by the input shaft **326** to the coupling head. The Applicants' Assignee's U.S. Pat. No. 5,993,454, DRILL ATTACHMENT FOR A SURGICAL DRILL, issued 30 Nov. 1999 and incorporated herein by reference, shows one such assembly. This type of attachment may be provided with a spindle and coupling assembly substantially identical to the spindle **42** and coupling assembly **46** of this invention.

The foregoing is directed to one specific version of the invention. It should be appreciated that alternative versions of the handpiece, cutting accessory and attachment of this invention may have features different from what have been described.

For example, there is no requirement that all handpieces of this invention include both the described clutch and coupling assembly. Some versions of the invention may have only the clutch or only the coupling assembly.

The gear train and drive heads of this invention may be of different design. For example, in some versions of the invention, the gear train may have three or more drive heads, each or which, in response to the single input rotational moment, operates at a different rotational speed. In some versions of the invention, the gear train has gears that cause one or more drive heads to rotate at speeds faster than those at which the motor shaft **26** rotates.

The means by which the motor **22** rotates shaft **26** may likewise vary from what has been described.

Similarly, the structure of the clutch **44** may differ from what has been described. For instance, some versions of the invention may have few or more laterally extending members, clutch pins or other torque transmitting components, for simultaneously engaging a gear train drive head **86** or **92** and the spindle **42**. In some versions of the invention, clutch **44** may even include a single one of these members.

In some versions of the invention, the inner shifter and/or outer shifter may be arranged so that the points at which longitudinal motion are transferred to this sub assembly (indentions **194** in the described embodiment) are within the longitudinal slice in which the lateral member that transfers torque from one of the drive heads to the spindle is located. Such construction can further reduce the overall longitudinal length of the clutch.

Also in some versions of the invention, the clutch pins may be integrally attached to the spindle. In these versions of the invention, the spindle itself is displaced in order to cause the clutch pins to engage the appropriate gear train drive head.

Similarly, in other versions of the invention, means other than a rotating shift ring may be employed to set the position of the clutch pins. In some versions of the invention, a switch member moveable mounted to the handpiece housing to move longitudinally is the surgeon-actuated component that is displaced to set the position of the clutch pins.

As seen in FIGS. **33** and **34**, it is possible to provide the clutch assembly of this with a tactile and audible feedback assembly for indicating the switching of the clutch between the clutch states. In the illustrated feedback assembly, the feedback is provided by a detent ball **340**. Detent ball **340** is seated in a bore **342** formed in the base **181*a*** of inner shifter **180*a***. The detent ball is positioned to extend inwardly, towards the outer coupler **124*a***. A spring **344** is also seated on inner shifter bore **342** so as to urge ball **340** inwardly, toward the outer coupler **124**. Shifter housing **186**, it is understood, is disposed over the inner shifter **180*a***. Thus, the inner annular wall of the shifter housing **186** functions as the static surface against which the outer end of spring **344** abuts.

The outer coupler **124*a*** has the same basic geometry of the first described outer coupler **124** (FIGS. **8** and **9**). Outer coupler **124*a*** is also formed to have two parallel arcuately extend grooves **348**. Grooves **348** are formed in the outer surface of the outer coupler **124*a*** between two adjacent slots **134** formed in the coupler. A first one of the grooves **348** is located adjacent the distal ends of the slots **134**. The second groove is located adjacent the proximal end of the slots **134**.

As the clutch is actuated, inner shifter base **181*a*** moves between the opposed ends of the outer coupler slots **134**. This movement of the inner shifter causes detent ball **340** to move out of a first one of the grooves **348** into the second groove **348**. The spring resistance overcomes moving the ball **340** out of the first groove **348** provides an initial tactile feedback that the clutch is being moved from a first state. When the inner shifter base **181*a*** is moved to the position wherein the clutch pins **184** engage the second one of the drive heads **86** or **92**, the detent ball **340** seats in the groove **348** aligned with the drive head. This results in an audible mechanical. Also, the individual actuating the shift ring **202** (FIG. **1**) is exposed to an additional resistance when try urge the ball out of the groove.

Thus, the feedback assembly of the clutch of this version of the invention provides feedback both when the clutch is moved from the first setting and when the clutch sets in the second setting.

Also, the structure of the coupling assembly **46** and complementary attachment/cutting accessory coupling head may vary from what has been described. There is no requirement that in all versions of the invention the surfaces of the spindle that output torque and complementary coupling head boss **302** have a hexagonal or even a polygonal cross sectional profile. It is believed that a polygonal cross sectional geometry is the most efficient for ensuring torque transfer to the coupling head.

Similarly, the coupling head body **304** may have a geometry different from what has been described and illustrated. There is no requirement that in all versions of the invention this component and the complementary spindle bore have circular cross-sectional profiles. In some versions of the invention, these components may even have one or more planar faces. It is believed though such geometry is an optimal geometry for reducing coupling head wobble. Similarly, there is no requirement that in all versions of the invention, the indentation defined by the coupling head body for receiving the locking member associated with the handpiece coupling assembly be an annular groove. In some versions of the invention, one or more indentations are provided in the coupling head body for receiving the complementary locking member integral with the complementary handpiece coupling assembly.

In some versions of the invention, the coupling body may not have any geometric features for receiving a complementary coupling assembly locking members. Also, there may be versions of the invention wherein the geometric features for facilitating the engagement of the handpiece coupling assembly with the coupling head project beyond the surface of the coupling head body.

Similarly, there may be versions of the invention in which the coupling head body has a diameter that is identical with that of the distally adjacent attachment/accessory shaft. In still other versions of the invention, the attachment/accessory shaft may have a diameter greater than that of the coupling head.

Likewise, an accessory/attachment coupling head of this invention may be constructed with geometric features different from slots **308** and beveled faces **312** to facilitate the alignment of the coupling head in the spindle bore. Some versions of the invention may not even be provided with any of these features.

Other coupling assemblies may, instead of holding an attachment/accessory coupling head to the spindle serve only to cause the coupling head to be driven by the spindle.

Therefore, it is an object of the appended claims to cover all such variations and modifications that come within the true spirit and scope of the invention.

What is claimed is:

**1**. A surgical tool comprising:
- a housing;
- a motor disposed in said housing, said motor having a rotating shaft;
- a gear train assembly mounted in said housing, said gear train assembly having a plurality of drive heads that are connected to said motor shaft to rotate at different speeds upon actuation of said motor shaft;
- a spindle rotatably mounted to said housing, said spindle shaped to receive a proximal end of a medical/surgical cutting accessory; and
- a clutch assembly disposed in said housing, said clutch assembly including:
  - an outer coupler having a distal end attached to said spindle to rotate in unison with said spindle and a proximal section attached to the distal end to rotate with the distal end, the proximal section disposed over said gear train assembly drive heads, the proximal section having at least one slot that extends over said gear train drive heads; and
  - a shifter disposed over said outer coupler and configured to rotate with and move longitudinally with respect to said outer coupler, said shifter including at least one pin that extends through the at least one slot of said outer coupler and that is moveable within the at least one slot, said pin being shaped to selectively engage either one of said gear train drive heads to transfer the rotational movement of the engaged drive head to said outer coupler and said spindle.

**2**. The surgical tool of claim **1**, wherein said shifter is a ring that surrounds said outer coupler.

**3**. The surgical tool of claim **1**, further including an actuator moveably mounted to said housing, said actuator being connected to said shifter for selectively displacing said shifter over said outer coupler.

**4**. The surgical tool of claim **3**, wherein said actuator is rotatably mounted to said housing.

**5**. The surgical tool of claim **1**, wherein said spindle is shaped to have a bore with a distal section that has a circular cross sectional profile and a proximal section that is defined by a plurality of faces internal to said spindle that are shaped to transmit torque to the proximal end of the cutting accessory seated in the bore.

**6**. The surgical tool of claim **1**, wherein a coupling member is moveably attached to said spindle to releasably hold the cutting accessory to said spindle.

**7**. The surgical tool of claim **1**, wherein said gear train reduces the speed of at least one said drive head relative to a speed of said motor shaft.

**8**. The surgical tool of claim **1**, wherein said gear train reduces the speed of said plurality of drive heads relative to a speed of the motor shaft.

**9**. The surgical tool of claim **1**, wherein said shifter has a maximum longitudinal length of 3.0 cm.

**10**. A surgical tool for actuating a cutting accessory having a shaft, said tool including:
- a housing;
- a motor disposed in said housing, said motor having a rotating shaft;
- first and second drive heads rotatably disposed in said housing, said drive heads being coupled to said motor shaft to rotate upon the rotation of said shaft, said drive heads being coupled to said shaft so as to, upon the rotation of said shaft, rotate at different speeds and being disposed in said housing so as to be coaxial with each other;
- a spindle rotatably mounted in said housing so as to be located forward of said first and second drive heads, said spindle having a distal section located forward of said drive heads that defines a bore for receiving the cutting accessory shaft;
- an accessory coupling assembly mounted to said spindle for removably holding the cutting accessory shaft in the spindle bore;
- a clutch assembly disposed in said housing, said clutch assembly including:
  - an outer coupler having a distal end attached to said spindle so that said outer coupler and said spindle rotate in unison, said outer coupler extending proximally over said first and second drive heads; and
  - a shifter, said shifter being ring-shaped and positioned to surround said outer coupler, said shifter configured to rotate with and move longitudinally with respect to said outer coupler and to selectively couple either of said first and second driver heads to said outer coupler so that said shifter, said outer coupler and said spindle rotate with the said drive head to which said shifter is coupled.

**11**. The surgical tool of claim **10**, wherein said spindle and said outer coupler are separate components that are attached to form a single-piece unit.

**12**. The surgical tool of claim **10**, wherein:
- an actuator is rotatingly mounted to said housing; and
- said shifter is located between said actuator and said outer coupler; and

said actuator and said shifter are connected together so that rotational movement of said actuator causes longitudinal movement of said shifter over said outer coupler.

**13**. The surgical tool of claim **10**, wherein a gear train connects said motor shaft to said first and second drive heads and said gear train reduces the speed of at least one said drive heads relative to a speed of said motor shaft.

**14**. The surgical tool of claim **10**, wherein a gear train connects said motor shaft to said first and second drive heads and said gear train reduces the speed of both said first drive head and said second drive head relative to a speed of the motor shaft.

**15**. The surgical tool of claim **10**, wherein said accessory coupling assembly includes at least one pin that is moveably mounted to said spindle and that extends laterally across the spindle bore, said pin being selectively positionable in the spindle bore to removably hold the cutting accessory shaft in the bore.

**16**. The surgical tool of claim **10**, wherein said shifter has a maximum longitudinal length of 3.0 cm.

**17**. The surgical tool of claim **10**, wherein:

said first drive head and said second drive head are each formed with a plurality of arcuately spaced apart notches; and

said outer coupler is formed with a plurality of slots that extend longitudinally along said outer coupler so as to extend over said first and second drive heads; and

said shifter includes a plurality of pins, said pins extending through the slots of said outer coupler and said pins being shaped so that, depending on the longitudinal position of said shifter over said outer coupler, said pins seat in either the notches of said first drive head or the notches of said second drive head.

**18**. The surgical tool of claim **10**, wherein:

said outer coupler is formed with at least one slot that extends longitudinally along said outer coupler so as to extend over said first and second drive heads; and

said shifter includes at least one pin, said at least one pin extending through the at least one slot of said outer coupler, said at least one pin being shaped so that, depending on the longitudinal position of said shifter over said outer coupler, said at least one pin couples said shifter to said first drive head or said second drive head so that said shifter, said outer coupler and said spindle rotate with said drive head to which said at least one pin is coupled.

**19**. A surgical tool comprising:

a housing;

a motor disposed in said housing, said motor having a rotating shaft;

a gear train assembly mounted to the housing, said gear train assembly having a plurality of drive heads that are connected to said motor shaft to rotate at different speeds upon actuation of said motor shaft;

a spindle rotatably mounted to said housing, said spindle shaped to have a bore with a distal section that has a circular cross sectional profile and a proximal section that is defined by a plurality of faces internal to said spindle that are shaped to transmit torque to a proximal end of a cutting accessory seated in the bore;

a coupling member moveably attached to said spindle to releasably hold the cutting accessory in the spindle bore; and

a clutch assembly disposed in said housing, said clutch assembly including:

an outer coupler having a distal end attached to said spindle to rotate in unison with said spindle and a proximal section attached to the distal end to rotate with the distal end, the proximal section disposed over said gear train assembly drive heads; and

a shifter disposed over said outer coupler and configured to rotate with and move longitudinally with respect to said outer coupler and to selectively couple said outer coupler to one of the drive heads so that said shifter, said outer coupler and said spindle rotate with the drive head to which said shifter is coupled.

**20**. The surgical tool of claim **19**, wherein:

said outer coupler is formed to define in the proximal section at least one slot that extends over said gear train drive heads; and

said shifter includes at least one pin that extends through the outer coupler at least one slot that is moveable within the at least one slot for selectively engaging one of the drive heads and transferring rotational movement of the engaged drive head to said outer coupler.

**21**. The surgical tool of claim **19**, wherein said shifter is a ring that surrounds the proximal section of said outer coupler.

**22**. The surgical tool of claim **19**, further including an actuator moveably mounted to said housing, said actuator being connected to said shifter for selectively displacing said shifter over said outer coupler.

**23**. The surgical tool of claim **22**, wherein said actuator is rotatably mounted to said housing.

**24**. The surgical tool of claim **19**, wherein the spindle and said outer coupler are separate components that are attached to form a single-piece unit.

**25**. The surgical tool of claim **19**, wherein:

said outer coupler is formed to have at least one slot in the proximal section that extends over said gear train assembly drive heads;

said shifter includes a pin that extends through the at least one outer coupler slot and is further positioned to engage either of said gear train assembly drive heads; and

an actuator is moveably mounted to said housing and is connected to said shifter so that displacement of said actuator causes a displacement of said shifter over said outer coupler that moves said pin between engagement with a first one of said drive heads to a second one of said drive heads.

**26**. The surgical tool of claim **19**, wherein said gear train assembly reduces the speed of at least one said drive head relative to a speed of said motor shaft.

**27**. The surgical tool of claim **19**, wherein said gear train assembly reduces the speed of the plurality of said drive heads relative to a speed of the motor shaft.

**28**. The surgical tool of claim **19**, wherein said shifter has a maximum longitudinal length of 2.0 cm.

**29**. The surgical tool of claim **19**, wherein said gear train is arranged so that said first and second drive heads are coaxial with each other.

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